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**FUNDAMENTAL THEORY AND PROBLEMS RELATED TO
LONG RANGE FORECASTING**

**Mission Identification Program
Phase I - Long Range Forecasting**

by

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FOREWORD

This study is a part of the Mission Identification Program; Phase I, Long Range Forecasting, and was performed under OAR Work Unit 7909-00-02, "Mission Analysis Methodology" by the Office of Research Analyses with the assistance of other organizations.

In this report, forecasting is interpreted in its most general sense; that set of processes, both logical and empirical, involved in obtaining decision information with regard to future conditions. It does not present a forecast or a method of forecasting. It is in essence an investigation of the fundamental theory and problems, and pitfalls, related to long range forecasting. The utility of this study is that it provides to those in the planning operation a clearer understanding of the forecasting process and hence should improve the quality of the forecasting art.



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ABSTRACT

Theory and Problems of Long Range Forecasting defines forecasting as a system of logical processes implicit in planning and decision making. The system is analyzed to components and functions. Key points and barriers to more effective operation are identified, with opportunities for avoiding or reducing some of the barriers, and promising avenues for further research. The alternative to effective forecasting is surprise. The characteristics of an effective forecast are reliability and relevance. Reliability is a function of consistent logics and valid premises, with the latter a major barrier. Relevance is the relationship between knowledge of facts and knowledge of human values, with the latter a present barrier. Criteria are developed for estimating the potential effectiveness of a given forecast or forecasting methodology. These criteria are combined in a structured series of questions for ease of application. Natural science and technological forecasting are found to be high in reliability but low in relevance for most planning and decision making. Social science and threat forecasting are typically high in relevance but low in reliability. Empirical research to increase the validity of social theories is the most promising avenue for improvement of forecasting, planning and decision making.

INTRODUCTION

The Mission Identification Program of the Office of Research Analyses was designed to assist Headquarters, Office of Aerospace Research and Headquarters, Air Force, in the tasks of long range policy, mission structure, force posture, research and development planning. All Air Force planning activities require information in regard to future threats against United States interests and security. Some planning activities, notably those involving basic research decisions, require threat information at time ranges up to twenty years in the future because of inherent lapse-times between initial decision and operational systems in the field.

Potential threats to United States interests and security arise from stresses within the international social, economic, political, military and technological environments. However, present state-of-the-art in the forecasting of these environments to a twenty year range leaves much to be desired.

With these considerations, definition of the Mission Identification Program recognized a need for further improvement of long range forecasting in general as a prerequisite of improved environmental projection, threat and mission identification, and thus improved information for Air Force planning activities. A basic research task addressing the theory and problems of forecasting anything was designated as part of the initial phase of the program. Study began in September 1966 and was completed in November 1968.

The method employed for this study is very similar to that used in technological barrier research, wherein complex systems are analyzed to their components and functions in order to identify key points and barriers to more effective operation, opportunities for avoiding or reducing some of these barriers, and promising avenues for further research. Based on this approach, the following topics are considered in this report.

1. Background discusses the context of forecasting, its relationship to planning, decision making and the ability to consciously direct change, the development of an accelerating demand for forecasts, and the development of efforts to meet this demand.
2. The Nature of Forecasting considers basic definitions, the system, its component processes and its products, the characteristics of an effective forecast and the consequences of ineffective forecasting.
3. The Problem of Reliable Forecasting analyzes the organization of knowledge, the roles played by various modes of reasoning with their typical strengths and weaknesses, the transfer and the quality of knowledge, as these relate to the problems and potentials of forecasting.
4. The Problem of Relevant Forecasts shows relevance as the relationship between knowledge of present or future facts and present or future values. From this reference, the normative aspects of forecasting are defined and discussed.
5. The Temporal Dimension considers the requirements for static and dynamic reference systems, time-series observations, and some of the problems typically associated with dynamics and causality. Areas for additional research are outlined.
6. The Matter of Biased Forecasts discusses the nature and symptoms of conscious and unconscious bias, as these appear in "self-defeating" and "self-fulfilling" predictions. Bias is shown to be a normative problem akin to salesmanship, which affects both relevance and reliability. Some approaches to the validation of biased forecasts are outlined.
7. Potentials for Increased Effectiveness combines the findings of earlier sections into a critical path network designed to maximize both reliability and relevance. Typical barriers and alternatives for avoiding them are identified. A list of criteria and pseudo-criteria of reliability, and a list of criteria for ascertaining the relevance of a given forecast to

the needs of a particular set of planners are presented. Attention is directed to the nature and criticality of key problem elements and subject areas which underlie barriers to both relevance and reliability at the present time. Avenues for improvement are suggested.

8. Conclusions lists those findings of the study considered to be fundamental to understanding the nature and problems of long range forecasting in any subject area, and to the progressive improvement of forecasting, planning and decision making in general.

Appendix A: An Interrogation Model for the Evaluation of Forecasts and Forecasting Methods is a structured series of questions designed to investigate the relevance and reliability of a given forecast or forecasting methodology. It provides information concerning needed basic research, requirements for empirical validation studies, and a fairly rigorous estimate of the potential effectiveness of forecasting in a given subject area.

Appendix B: Customers' Checklist is an abbreviated interrogation model designed for use by planners and decision makers who do not have time to go through a detailed evaluation, but nevertheless wish to assure themselves that the major points have been considered.

The author recognizes the extreme difficulty inherent in forecasting and the improvement of forecasting. The present study is not considered to be final, but only one attempt to apply the systems approach to the apparently endless task of progressively reducing uncertainty. It is not designed to provide a forecast or a method of forecasting, but only to assist in some small measure those who are charged with so doing. Whatever utility this study may have must rest with the practicing forecaster, planner and decision maker.



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TABLE OF CONTENTS

	Page
I. BACKGROUND	1
1. Context	1
2. Forecasting, Planning and Decision Making	3
3. Development of Demand	3
4. Development of Supply	6
II. THE NATURE OF FORECASTING	8
1. Analysis of Definitions	8
2. Synthesis of Definitions	17
3. Discussion of Implications	19
4. The Characteristics of an Effective Forecast	23
III. THE PROBLEM OF RELIABLE FORECASTING	24
1. The Logic Cone: An Exploratory Model	24
2. Generation of Knowledge: Induction	33
3. Application of Knowledge: Deduction	41
4. Quality of Knowledge: Validation	46
5. Problems of Mode	58
IV. THE PROBLEM OF RELEVANT FORECASTS	71
1. Reality and Potential Reality	72
2. The Realms of Knowledge: A Model	76
3. Problems of Realm	84
V. THE TEMPORAL DIMENSION	98
1. Reference Systems: Static and Dynamic	99
2. Problems of Dynamics	101
3. Cause and Effect	107
4. Summary	108

VI. THE MATTER OF BIASED FORECASTS	108
1. Normative Bias	109
2. Self-Defeating and Self-Fulfilling Forecasts	112
3. Validation of Biased Forecasts	115
4. Summary	123
VII. POTENTIALS FOR INCREASED EFFECTIVENESS	124
1. Improving Reliability	126
2. Improving Relevance	139
3. Combined Improvement	151
VIII. CONCLUSIONS	155
REFERENCES	163
BIBLIOGRAPHY	168
APPENDIX A	
AN INTERROGATION MODEL FOR THE EVALUATION OF FORECASTS AND FORECASTING METHODS	
1. General Structure of the Model	179
2. Interrogation for Demand	181
3. Interrogation for Underlying Cause	184
4. Interrogation for Supply	188
5. Interrogation for Relevance	192
6. Interrogation for Reliability	194
7. Estimation of Potential Effectiveness	205
8. Interrogation Model Read-Outs	206
APPENDIX B	
CUSTOMER'S CHECKLIST	
	207

LIST OF FIGURES

<u>Figure</u>		
		<u>Page</u>
1. Implications	20	
2. Premise.	24	
3. Venn Diagram	25	
4. Venn Diagram, Extended	26	
5. Nested Triangles	27	
6. Cone	29	
7. Induction	34	
8. Deduction	42	
9. Authentication (rational validation)	49	
10. Verification (empirical validation)	54	
11. Reality, Potential Reality, and Knowledge.	73	
12. Realms of Knowledge	77	
13. Characteristics of an Effective Forecast	125	
14. Factors of Reliability	127	
15. Alternate Means of Validation	130	
16. Requirements of Empirical Validation	131	
17. Alternative Means to Avoid the "Time Barrier"	134	
18. Factors of Relevance	141	
19. Requirements of Decision	142	
20. Analysis of Demand.	144	
21. Analysis of Future Supply	148	
A1. Overview of the Model	180	
A2. Interrogation for Demand	182	
A3. Interrogation for Underlying Cause	186	
A4. Interrogation for Supply	190	
A5. Interrogation for Relevance	193	
A6. Interrogation for Reliability	195	

FUNDAMENTAL THEORY AND PROBLEMS RELATED TO LONG RANGE FORECASTING

I. BACKGROUND

For the purposes of this study, forecasting is defined in its most general sense; i.e., that set of processes involved in obtaining information in regard to future conditions. This broad definition was chosen in order to establish a frame of reference which would not arbitrarily exclude any conceivable means of obtaining such information. The concept of "process" was indicated by our overall objective of improving the product, and our preference for a systems approach. Section II, The Nature of Forecasting, will tighten this definition by specifying the processes involved.

1. Context

In this general sense of the term, there is nothing new or unique about forecasting; both the desire and the ability are probably as old as the human race. Anticipation and prejudice, hope and dread, threat and promise, superstition and scientific prediction all share the common property of referring to future conditions or the expectation of future conditions. Such expectations, in one form or another, appear to be a natural and universal characteristic of human beings.

Why do we concern ourselves with the future? Why not simply wait and take things as they come? In other words, what is the use of trying to forecast anything?

We do so because the "power of prediction" is more than an idle combination of words; the ability to forecast is one of mankind's most basic tools.

For thousands of years, man has been notable for not only adapting himself to his environment as other species, but for persistently attempting to adapt his environment to himself. Because the word "environment" implies "surroundings," man's environment includes himself and the

institutions he has created. To adapt something means to alter or change it in a specific way. Thus, man typically causes changes which would not occur if the non-human world were left to itself. Further, he usually does this with some purpose or goal in mind. He not only attempts to cause change, but to direct it as well.

It is in this context that the ability to forecast represents a major tool of the race. We are powerless to alter the past, and relatively powerless to alter the present. (Ref 1) Only through the future effects of our present actions do we actually influence our environment. Even there, we are limited by the relatively small amounts of biological energy we have inherited. It is the ability to forecast which allows us to anticipate natural dynamics, to obtain previews of desirable and undesirable conditions, and to foresee the potential consequences of our own actions. Because the power of prediction implies the ability to see the outcome before the act, it further implies the possibility of choosing between alternative actions (or non-actions) before making a commitment to any of them.

Through the selective and timely application of our small energies made possible by the ability to forecast, we are able to set into motion cumulative effects within the natural dynamics which then amplify our energies and provide the desired results. While it is true that we can cause changes which we cannot predict, and that we can often predict changes which we cannot cause, it is only when we are able to combine both the power of prediction and our small power of causation that we attain to effective power in the fullest sense of that term: the ability to consciously direct change. This is the utility of forecasting: that it forms a prerequisite of such power.

2. Forecasting, Planning and Decision Making

From this discussion, it may be seen that all planning and decision making requires some form of forecast, no matter how quickly and intuitively derived. A plan is essentially a decision or series of decisions made in advance for the purpose of directing change; decision is a conscious choice between perceived alternative courses or actions. Thus, it is impossible to make either plans or decisions without also making forecasts about the likely outcome of each alternative; the forecast is implicit in the plan.

Because a forecast is implicit in any plan, the planner does not have a choice as to whether he will make a forecast. He does, however, have a choice as to whether the forecast will be made openly, objectively and systematically so it may be subjected to the review and criticism of others, or intuitively, subjectively and arbitrarily, thus making review and criticism difficult or impossible. It is just such review and criticism which is required for the progressive refinement of forecasting. (Ref 2)

3. Development of Demand

An intuitive recognition of the power inherent in the ability to forecast has led to a long series of efforts to improve it, this study being only one of the more recent. The search itself has provided motivation for scientific development, and the acid test of scientific hypotheses. It has also led into the areas of prophecy, astrology and augury. The urgency of this recognized need for better forecasting has not diminished over the years, and has increased rapidly in the last quarter century, due to the combination of several facilitating factors.

One of these factors has been the continued evolution of responsible leadership. In modern political, economic and military environments, individual leaders are increasingly held accountable for the results of their decisions. The statesman, manager or commander who leads his

organization into dire straits through a lack of foresight is far less immune to replacement than he was formerly. Thus, accurate foresight has become a criterion for the continued exercise of authority, to some degree replacing the right of birth, of wealth, and similar criteria. The result is an increased demand for the services of professional forecasters and advisors to augment the leader's own abilities.

A second impetus for looking ahead came about as a side-product of the scientific and industrial revolutions. As continued development in these areas became disseminated into operational technology, it dramatically increased man's capability to alter his environment. Increased capability implies an increase in the number of alternatives available, and thus an increased need to forecast the potential consequences of each before making a choice among them. Increased capability also implies more far-reaching effects, in scope and in time. The consequences of modern technology range far beyond our present ability to foresee them. Concern as to whether such effects will lead to desirable or undesirable conditions has increased the demand for improvement of forecasting.

(Ref 3)

Also from science and technology has come an accelerating rate of change. We speak of an increasingly dynamic world. In a static situation, or one where change is very slow, forecasting is extremely simple: the future will be the same as the past and present. In an absolutely random situation or one where every change is unique, forecasting is impossible. Between these two limits, the need for accurate foresight is directly related to the rate of change. The faster things are moving, the farther ahead and the more clearly one needs to see. Both delayed response and overcorrection are symptoms of inadequate foresight.

A third source of demand for improved forecasting came about primarily in the United States as a great but subtle shift of attitude during

World War II. Subsequently, it spread to almost all countries, or to groups within those countries, through the explosive impact of modern communications. In the United States and some western countries, the masses of people began to look to the future in a different way. Deferred spending and consumption, postponed families and educations, anticipated housing, business, social and technological opportunities all contributed to the expectation of an attractive future, rather than a dark and fearful unknown. "After the war..." became the slogan of anticipation. Personal, social, corporate and national planning for such a future became habitual, and even the uncertainties inherent in forecasting have not returned the majority to its traditional orientation of looking only to a comfortable and understandable past.

In other countries, people also began to be concerned with the future. They compared their present and projected conditions with those of other, more developed nations, classes, or individuals. The contrast in many cases was seen as intolerable, but no longer impossible to remedy. The result was a "revolution of rising expectations," increased pressure for attainment of these expectations, and so increased demands on forecasters, planners and decision makers.

A fourth type of demand pertains to the range of forecasts. The utility of increased range was demonstrated by a number of instances wherein actions based on short range forecasts tended to defeat their original purpose in the longer range. One such example was the launching of Sputnik I, which temporarily increased Soviet prestige at the subsequent cost (to them) of stimulating United States missile and space programs, research, and scientific education. Another was the U.S. support of dictatorial regimes as a defense against communist insurgency, which in some cases such as Batista's Cuba served to increase popular unrest, and so opened the door to the very thing it was designed

to prevent. And a third was the overemphasis on heavy industry in countries like India before an adequate base of food production, population control and national infrastructure was established, which, contrary to optimistic forecasts, acted to dilute economic development rather than to accelerate it.

This discussion of the demand for forecasts may serve to illustrate the direct relationship between the ability to forecast and the number of alternatives available for decision. Increased availability of alternatives implies increased need to forecast their consequences, but increased ability to forecast also implies increased latitude for choice through identification of otherwise unperceived alternatives. Developed countries tend to find themselves in the former condition, and the less developed in the latter. Both require improved forecasting, planning and decision making, although for different reasons.

4. Development of Supply

With such a widespread and urgent demand established, planners of all sorts have attempted to extend forecasting in both range and scope. In the United States, the concept of cost-effectiveness was initially introduced to evaluate current operations, but soon showed even greater potential when applied to proposals. When it was directed to the evaluation of development programs, and then to basic research and policy decisions, the cost-effectiveness concept led long range planning and its attendant, long range forecasting, outward in time from one year to three years, then to five, ten, twenty, and in some cases, fifty years. At the present, short range forecasting is generally understood as implying ranges up to five years, midrange five to ten years, and long range from ten to twenty years. These are not, however, definitions. For this study, long range forecasting is considered to lie in the vicinity of twenty years.

As the range of forecasting expanded, so has the scope of subject matter and the number of institutions involved. Forecasts are now available on subjects ranging from family genetics and election returns to solar cycles, atomic proliferation and urban renewal.

For their own survival in a competitive environment, business and industry have included forecasters in both their marketing and production divisions; national governments have established special advisory boards, "brain trusts," and "task forces." Some of these have become permanent institutions or departments of government. Technological forecasting, with its importance to military, industrial, and national planners, has developed from the hazy conjectures of the war years to a major enterprise affecting the highest level of corporate and national decision. (Ref 4)

Added to these "serious" or professional forecasters are the much larger numbers of no less serious but often less professional efforts on the part of experts in nearly every field. Today nearly every book, article or report may be expected to conclude with a forecast; a public speech without a prediction is rare, and the popular information media are saturated with various opinions of future conditions. In sum, there is absolutely no shortage of forecasts or forecasters.

However, despite the profusion of predictions, demand continues to increase. Apparently this is because the true demand is not only for more forecasts and more forecasters, but for more effective forecasts. Here there remains a definite shortage, and an area for continuing improvement.

II. THE NATURE OF FORECASTING

In attempting to assist in the improvement of forecasting, we are forced to ask ourselves a number of questions. Among these are: What is forecasting? What does the forecaster try to do, and what does he actually do? What are the distinguishing characteristics of various approaches to forecasting, and what elements or functions do they hold in common? What constitutes an effective forecast, and how does one recognize potentially ineffective forecasting?

Our approach to these questions will be through the analysis of definitions, followed by a synthesis of their implied meanings. From this approach we would hope to obtain a deeper insight as to the nature of the subject at hand. Although a glossary of definitions more properly belongs in an appendix, it is placed in the front of this report because an agreement as to meaning is a prerequisite for following discussions. As subsequent sections expand on these definitions, the reader may wish to refer back to this section.

1. Analysis of Definitions

Unless otherwise specified, all definitions will be drawn from Webster's New World Dictionary of the American Language, 1965 College Edition, to include the shades of meaning found under various synonyms and antonyms. This tactic was chosen in an effort to reduce the numerous semantic difficulties encountered in this field due to specialized and personalized usage, and to establish a common ground for discussion in a readily available reference.

a. Foretell, according to Webster, is the most general term for any telling or indicating beforehand, and does not in itself suggest the means employed. This would make it appear that foretell defines a universe of discourse including any conceivable means of obtaining foreknowledge, which is the context we wish to investigate. However, closer

inspection shows that "telling or indicating" refers only to the set of techniques whereby foreknowledge may be displayed or transmitted, and tacitly excludes consideration of the underlying process or processes by which it is obtained. Thus, the term is inadequate for our purposes, and will be confined to usage as a synonym for display techniques.

b. Foreknowledge refers to knowledge of something before it happens or exists. Knowledge applies to any body of facts gathered by study, observation, etc., and to the ideas inferred from these facts. Unlike its synonym, information, knowledge also connotes understanding or validity. Thus, foreknowledge may be interpreted as meaning valid information or understanding of what will happen or exist in the future, made available before the event. The term would appear to adequately denote the product we wish to obtain.

c. Foresight is defined as a seeing or knowing beforehand, the power to foresee, any looking forward, or a thoughtful regard or provision for the future; prudent forethought. Thus, it refers to the output of a process, an ability, an attitude or orientation, or to one characteristic quality of wisdom. "He shows great foresight" is a tribute men pay to their most successful leaders; "shortsighted" is often a contemptuous opposite.

The use of visual analogy appears significant; range, scope and clarity are analogous between sight and foresight. So is "point-of-view" or perspective. However, in reference to the process, this analogy breaks down. Sight is accomplished through biological receptors, but insofar as we are now aware, we have no such receptors capable of obtaining information from future time. For this reason if for no other, a primary characteristic of future time is that all phenomena are non-observable, becoming so only as they enter the present. Direct observation of future conditions is impossible.

Thus, foresight would appear most useful if restricted to mean that attitude or orientation in regard to time which is characteristic of wisdom.

d. Prophecy refers specifically to the process of obtaining foreknowledge through divine or occult revelation. It implies the disclosure of something not previously known or realized.

This entire area has been prejudged as taboo for many years, and so removed from any serious consideration. However, the statements of saints, seers, prophets and oracles do fall within the realm of foreknowledge, and in many cases appear to hold some correlation to subsequent reality. (Ref 5) Rather than a priori "belief" or "disbelief" (both symptoms of pre-judgment), scientific objectivity would indicate reservation of judgment and thorough investigation. If there is more in this area than rumor and myth, and such a capability does exist, it could prove most useful.

The major problem with prophecy is that the process is only named, and not explained, even by professed practitioners. Therefore, it is not replicable, cannot be evaluated systematically or taught to others, gives no basis except faith in the source for placing confidence in its product, and so cannot be applied as a general method. Recent efforts in psychic research and parapsychology may hold promise of reducing this problem, (Ref 6) possibly by defining and explaining extrasensory capabilities in human beings through which direct observation of future conditions may be attained. However, pending such a breakthrough in psychic research, these sources of foreknowledge must either be taken on faith, or held in reserved judgment while we look for more replicable methods.

e. Prediction is the statement, or act of stating what will be; to make known beforehand, to foretell; it suggests deduction from facts already known or the use of scientific calculation.

In this definition we find the implications of reliability, accuracy and high confidence so often associated with this term. In the sense of high quality forecasting, prediction stands in contrast with terms such as speculation, conjecture and guesswork, all of which carry the connotation of risk or risky ventures, high probability of error, and thus low confidence in the product. The quality we wish to maximize for improvement of forecasting conforms to this sense of the term prediction, and the quality we wish to minimize is probability of error or risk. In this context, the two may be seen as inversely related.

Because prediction refers specifically to future time, it may also be contrasted with retrodiction; to infer a past state of affairs from present observational data. Thus, the contrast between prediction and retrodiction refers to direction over time. (Ref 7)

By stating that prediction suggests deduction, this definition may also provide another hint as to the nature of forecasting. Deduction is a specific mental or logical process defined as; reasoning from a known principle to an unknown, from the general to the specific, or from a premise to a logical conclusion.

From this analysis, we find the word prediction may refer to a process, the product of that process, a high quality product, or to one direction in regard to time. Rather than specify which sense of the term is being used each time it appears, we will substitute deduction for the process, foreknowledge for the product, reliability for the quality of product, and reserve prediction to its sense of reasoning forward over time.

i. Conjecture is guesswork; inferring, theorizing or predicting from incomplete or uncertain evidence. Guesswork is the formation of a judgment or estimate without actual knowledge.

Both of these terms carry the connotation of high risk or low quality. Since we find prediction used to define conjecture, it must be used in the directional sense because the implications of quality are opposed. The suggestion is that conjecture also employs the process of deduction, but from assumptions or opinions which have not been well established by evidence. Guesswork would suggest a lower degree of quality wherein deduction is based on unfounded opinion and complete lack of evidence.

g. Prescription originally meant something written out beforehand; hence, a rule, direction, order, policy, etc.

The term differs from prediction in that it does not pertain to what will be, or will be done, but to what ought to be, or should be done. Prescription is the projection of values or value judgments, where prediction is the projection of facts or factual judgments. Both are based on present knowledge, but on different types or realms of knowledge. The processes appear to be identical, and both are found in forecasting, planning and decision making.

h. Projection has three meanings: It may refer to anything hurled forward, to the proposal of a plan, or to the act of sending forth one's thought or image.

The first of these meanings is rather too general for our purposes, and the second refers to a subsequent process -- planning -- that takes a forecast or forecasts as input. The third meaning, however, seems singularly appropriate. For all our efforts, we do not actually place anything into the future by forecasting. The curve we draw across a chart may depict "past," "present," and "future;" and we may read it in either direction, but it still represents no more than the knowledge or opinion of its producer at the time of production. The mental images we project over time exist only in the present, and are themselves subject to change.

Because we may send forth our thought or image toward past, present or future, the term projection would appear to define a class of mental activities of which prediction and retrodiction are specific cases referring to future and past time, respectively. A third case, referring to present time, may be seen as explanation; i.e., to make clear, plain or understandable something that is not known or understood.

These three terms -- retrodiction, explanation and prediction -- may be seen as the projection of one's thought or image through the process of reasoning deductively from present knowledge or opinion to illuminate the past, present or future unknown.

i. Prognostication is the process of obtaining views of the future through study of signs and symptoms. Historical analogy is a common synonym; precursor analysis is a more technical equivalent, and prognosis refers to its application by the medical profession. All of these represent forecasting by analogy.

The basic assumption of forecasting by analogy is that of repetition; i.e., that like causes will produce like effects, or that patterns of change observed in the past will repeat again under the same conditions in the future.

The process operates by: (1) extensive observations and recording of observations, (2) study of these observations to identify patterns of change, (3) study of current observations for those signs, symptoms or precursors which represent early stages of recognized patterns, and (4) projection of future conditions implied by later stages of the appropriate pattern.

Strengths of this process are that assumptions of cause and effect, sequence, conditions and parameters, and the comparability between symptoms may be made explicit, recorded, and subjected to review and criticism. Thus it is a replicable process which may be taught, learned,

and refined. Much of the predictive power in the natural sciences has been developed through the progressive refinement of analogies, often expressed in the form of mathematical equations.

j. Extrapolation also refers to a specific process: to estimate or infer a value, quantity, etc., beyond the known range on the basis of certain variables within the known range, from which the estimated value is assumed to follow.

The most general synonym for extrapolation is trend forecasting, which includes the projection of: (1) no change, (2) linear momentum, (3) curvilinear acceleration, and (4) higher order functions such as cycles and harmonics. Parametric extrapolation projects upper and lower limits, and probabilistic extrapolation projects the likely distributions within such limits. When more than two dimensions are considered (with one dimension representing time), extrapolation will produce various cones, envelope curves or topographical projections.

The basic assumption of all extrapolations is that of continuance; i.e., that the observed pattern of change will continue into the future. Like forecasting by analogy, the process requires: (1) observation and the recording of observations, (2) identification of patterns (trends) within the observed data, (3) a point of departure in present or some arbitrary reference time (T_0), and (4) projection of future conditions implied by continuance of the identified trend.

The main strength of extrapolation is also replicability. The process may be taught, learned, subjected to review, and so progressively refined. It may also be accomplished rather quickly and easily; its sophistication is limited only by computer design, and its scope by data and computer memory availability. Graphic display techniques are a natural output, and these are easy for most people to follow and comprehend.

k. Forecast is defined as coming close to predict; it implies the estimation of probable course or future condition. All four elements of this definition -- estimate, probable, course, and condition -- appear to be significant. So does the observation that forecast and predict are in some way closely related but not identical.

(1) Forecast and Predict apparently differ only by degree of confidence in the product. Both form a mental image of the future by deduction from present knowledge, but a prediction is based on facts or positive knowledge which is considered to be nearly certain, while a forecast is based on knowledge which is only more or less exact. Thus, the processes are identical, but the quality of product varies in direct proportion to the quality of the inputs, which are present knowledge, opinion, or guesswork.

(2) Estimate is to form an opinion about something; to gauge, judge or determine roughly, an approximate calculation. An opinion is a belief -- the mental acceptance of an idea or conclusion -- but one which is not based on absolute certainty or positive knowledge. Approximate is to come close but not attain; in this sense it means more or less exact.

(3) Probable and Probability, with a group of their associated terms, now have two distinct meanings depending on the context in which they are used. The two contexts in question are mathematics and decision making. The former employs the statistical and the latter the subjective sense of these terms. Although both use the same words, they are not talking about the same things.

This ambiguity of meaning underlies much of the present debate between the so-called "quantitative" and "qualitative" schools or approaches, and many of the communication difficulties between statistical analysts or forecasters and the decision makers who typically employ them.

It also requires one to decide in which sense he should approach the probability that a given forecast will prove to be reliable.

(a) Natural or Statistical Probability is the mathematical theory of those uncertain events which fall within the range of known possibilities. The range of known possibilities is from the certain to the impossible case. In this context, all three terms -- certain, possible, and impossible -- refer to known or given conditions. Uncertainty applies only to the distribution of specific events within these known parameters. The concept of probability refers to these specific events, is included in the possible range, and bounded by the certain and impossible events or cases.

(b) Judgmental or Subjective Probability is the degree to which a person can reasonably believe in any given statement or conclusion based on incomplete or uncertain evidence. In this context, the probability that a given statement is either true or false is seen as ranging from possibility to certainty. Here, possible means conceivable but neither proved nor disproved; thus, it implies indeterminate verity or lack of positive knowledge, and is distinguished from probable. Possible means something that can reasonably be expected or believed on the basis of available evidence, though still not absolutely proved or certain. Certain and impossible both mean known (as true or false), in the sense of having been proved so by sufficient evidence. Uncertainty has the connotation of doubt; i.e., a lack of conviction or belief due to absence of sufficient evidence. It may range in implication from a mere lack of absolute sureness to such vagueness as to preclude anything more than guesswork.

In forecasting, the scale of implied confidence or reliability -- which ranges from guesswork and speculation, through estimation, to scientific prediction -- follows the subjective rather than the statistical definition

of probability. Thus, present statistical theory is not relevant to this problem, and will become so only when and as subjective theory is developed to a point where limits and parameters are adequately defined and established by the evidence.

(4) Course refers basically to dynamics. It is given with a large number of connotations, but all of these imply the direction (trend) or the pattern (analogy) of some particular motion. All concepts of continuance, repetition, momentum or acceleration may be subsumed under this more general term.

(5) Condition refers to the set of circumstances surrounding or characterizing a person or thing at a given time. Surroundings imply environment; characteristics imply internal properties, attributes or states. Person and thing, when taken together, may refer to any conceivable entity, living or non-living, at any order of abstraction. Thus, while the scope of subjects to which this word may be applied is equal to that of human imagination, it will in all cases pertain to the fixing of some motion at a particular instant in past, present, or future time. As course subsumes all concepts of dynamics, so condition includes all concepts of statics.

2. Synthesis of Definitions

Observations resulting from an analysis of definitions may be compiled according to their commonalities and differences. Such a compilation can provide insights as to the elements of the system.

a. Display Techniques are employed to make the products of forecasting understandable to others. These techniques include all conceivable means of telling, indicating or depicting.

b. Reliable or Accurate Forecasting is considered a utility, a characteristic quality of wisdom, and is thus to be maximized. Errors in forecasting are a disutility, and are to be minimized.

c. Foreknowledge is the product of forecasting, but it exists only in the present and is itself subject to change.

d. A Spectrum of Quality is found in forecasting and in its product. This spectrum ranges from sheer guesswork to scientific prediction. It corresponds to expectable confidence in the product, which is the same as reliability. It also corresponds to the definition of subjective probability and to the degree of evidence in support of an opinion.

e. Blind Faith or Certitude, which is the holding of opinions in the absence of evidence or in spite of the evidence, is a factor in forecasting. Certitude may apply to believing that something is either absolutely certain or absolutely impossible.

f. Future Time Characteristically Presents No Observable Evidence. We have neither natural nor technological sensors capable of direct observation of future conditions.

g. All Predictable Processes Involve the Compilation of Sequential Observations. This excludes only prophecy and intuition, and there is some question if they may not also involve a subconscious accumulation of information.

h. All Processes Include Postulation, which is the formation of an opinion, hypothesis or law concerning patterns of change. Reliability follows -- at least in part -- the degree to/ which these opinions are supported by observed evidence. Additional observations may assist in supporting or denying these opinions.

i. All Processes Include Projection, which is deduction over time. This is accomplished by reasoning from the presently known or believed, where premises contain a time function, rate, or assumed pattern of change, to the necessary consequents of these premises, which refer to another point in time. Prediction is the projection of factual judgments forward over time; prescription is the projection of value

judgments forward over time. Explanation and evaluation project knowledge of facts and values to the present unknown. Prediction and re-evaluation project knowledge of facts and values into the past.

j. The Two Basic Assumptions in regard to change over time are that patterns of change will continue (trend extrapolation) or repeat (prognostication by analogy). These are fundamental to the replicable processes, and very likely to intuition as well.

k. Forecasting May be Applied to Any Ongoing Subject.

Because it includes all conceptions of static conditions and dynamic changes, knowledge of facts and knowledge of values, forecasting is limited only by complete lack of information, which is absolute ignorance of the subject under consideration. The scope of possible applications thus includes all of human knowledge, opinion or imagination except that specifically confined to past conditions.

3. Discussion of Implications (Figure 1)

By analysis and synthesis of definitions, we have identified some properties, dimensions and components of forecasting. We will now attempt to integrate these pieces into a more comprehensive picture of the overall system and its implications.

a. Functional Components of forecasting appear to be a set of mental activities, implicit or explicit, applicable to any conceivable ongoing subject area, by which men obtain present opinions as to future conditions. These activities include: (a) making observations sequentially over time, (b) recording or remembering these observations, (c) drawing assumptions as to the patterns of change suggested by the observations, (d) assuming these patterns of change will either continue or repeat, (e) deducing from these assumptions what the future will or should hold, and (f) recording, remembering, displaying or transmitting these conclusions.

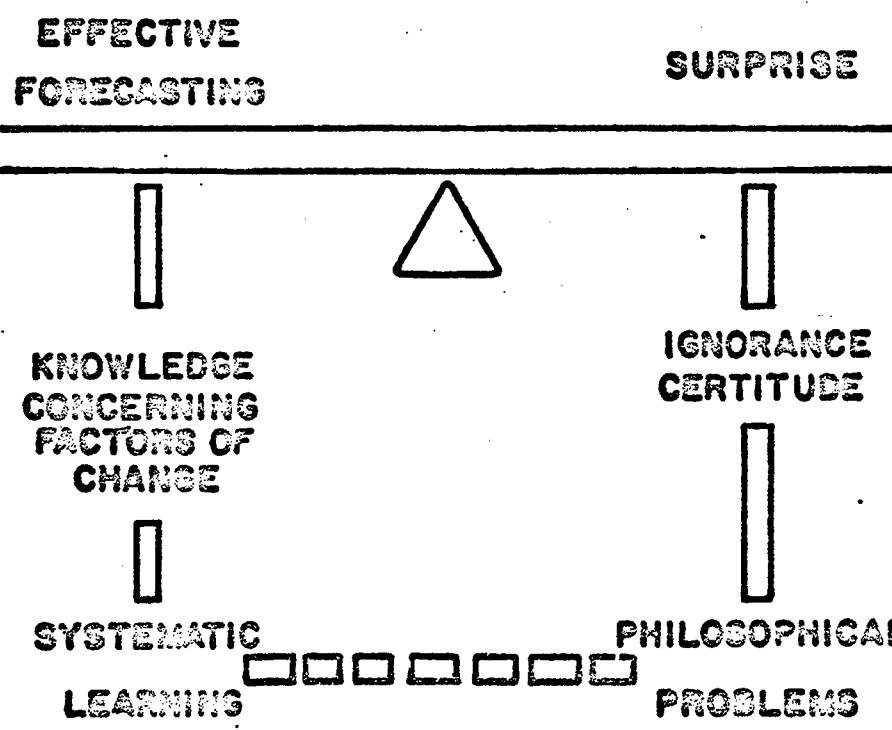


Figure 1. Implications

b. Reliability or the Power of Prediction appears to be a product of the availability and quality of knowledge. Where knowledge is not available, regardless of subject, ignorance prevails and forecasting is impossible. When the passage of time brings unknown and thus unexpected situations into reality, the result is surprise -- the symptom of belated recognition. Where the quality of knowledge is low due to guesswork or assumptions inadequately supported by observed evidence, forecasting is to the same degree ineffective and surprise is to the same degree more likely. Surprise and reliable forecasting are inversely proportional.

At various times in the past, many subjects have been considered inherently unpredictable. These have ranged from the motions of planets and the functions of living systems to the dynamics of human affairs. In each case to date, the deficiency has been found in a lack of valid knowledge, rather than in the subject itself. On the other hand, the assumption of unpredictability -- the "impossible" aspect of certitude -- has itself been a major barrier to the development of predictive power. When one assumes something cannot be done, and then neglects to question his own assumptions, he is less likely to try and so less likely to succeed.

Conversely, the assumption that the future is already known or predetermined -- the "certain" aspect of certitude -- makes the idea of forecasting seem unnecessary. Those who think they already know do not ask, and so are less likely to discover their errors. As ignorance makes forecasting impossible, so certitude in any of its aspects makes the improvement of forecasting impossible.

c. Relevance of a Forecast pertains to the relationship between those subjects selected for projection and the subject area in which foreknowledge is desired. Very little of modern forecasting is conducted as a purely scientific or academic exercise. Most forecasts are initiated for the specific purpose of furnishing decision information to a particular

set of planners. If the knowledge employed in the forecast is not relevant or only partially relevant to the nature of these planners' subject area, the forecast will be less effective for exclusion of significant elements. The excluded elements will continue to exert an influence for change over time, and since these changes will not be accounted for in the forecast, it will become progressively less accurate and the potential for surprise will become progressively greater. As use of irrelevant subjects makes a forecast possible but ineffective in accomplishing its intended purpose, so use of partially relevant subjects makes the forecast progressively ineffective over increased time ranges. Since more factors may be expected to contribute an influence for change over increased ranges, the scope of subjects relevant to a given forecast will also increase in direct proportion to the desired range.

Portions of a forecast may be excluded for two reasons: first, we may not realize they exist or that they will exert an influence for change in the subject under consideration. This is ignorance. Second, we may simply assume particular factors will not be relevant to our subject area, or that they will remain constant over the forecast period. This is again a form of certitude.

d. Barriers and Potentials. Thus, we find ignorance and certitude as the fundamental barriers to effective forecasting, planning and decision making. In the area of reliability they lead to immediate surprise, and in the area of relevance, to progressive surprise. We also find the systematic selection, acquisition, organization, validation and application of knowledge to be the avenue for improvement. Since these barriers and potentials for improvement are common to all subjects, we find no functional difference between the forecasting of social, economic, political, military, technological or natural phenomena. The process, the problems and the potentials for improving our ability to

forecast are all essentially philosophical, rather than being the exclusive property of any given subject area.

4. The Characteristics of an Effective Forecast

Whether one forecasts by analogies, trends, or both, the knowledge employed for this purpose must have two essential qualities: reliability and relevance. Reliability refers to the power of prediction or level of expectable confidence, and relevance means a direct relation to the needs of those planners and decision makers who intend to use the forecast as decision information. These are the characteristics of a good forecast.

If the knowledge is not reliable, but merely unfounded speculation or intuition, the forecast will present a distorted view of the future and plans based on that forecast will lead to surprise. This is true regardless of the display technique employed or the degree of sophistication.

If the knowledge is not relevant or only partially relevant to the nature of planning problems, the forecast will be less effective for the exclusion of significant elements. These excluded elements will exert their influence over time, making the forecast progressively inaccurate and the potential for surprise progressively greater. While it is impossible to include all factors relevant to the forecasting of large and complex systems, effectiveness may be increased by including those which account for the major changes.

Thus, the two characteristics of reliability and relevance are both necessary, but neither is sufficient for effective forecasting, planning and decision making. Each of these characteristics will be taken as a separate problem area, and the factors underlying each will be considered in greater detail.

III. THE PROBLEM OF RELIABLE FORECASTING

A reliable forecast is one which accurately portrays a specified portion of future reality. In order to approach our objective of ascertaining how such forecasts may be identified or produced, it will first be necessary to investigate the process of forecasting in greater detail. Since any forecast -- reliable or not -- is produced by human reasoning, this inquiry must consider the forms, functions and limitations of logic. As a frame of reference for studying logic, it must also deal with the manner in which knowledge is organized. This is the study of epistemology. Thus we will begin with the structure, work to functions of reasoning, and from these attempt to identify underlying strengths and limitations pertinent to the problem of reliable forecasting.

1. The Logic Cone: An Exploratory Model

While there have been many conceptual models advocated for the purpose of illustrating how knowledge is organized, the following has been found most useful in the evaluation of forecasts and forecasting methods. It is also a hypothetical construct, a model, designed to incorporate some of the more common properties of organized knowledge, as these are observed in forecasting. It is designated as exploratory because further refinement is necessary before it might be considered as explanatory.

The basic premise of this model is that knowledge is organized in the form of a cone. (Figure 2)

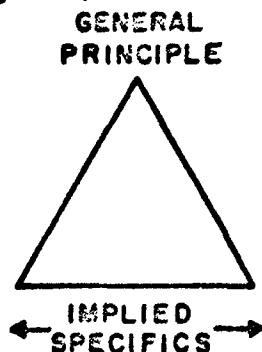
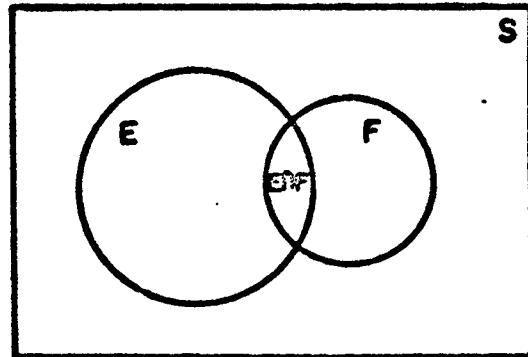


Figure 2. Premise

Any body of knowledge is arranged between a few general principles and a larger number of specific concepts. Within such a body, each generality will include or imply an increasing number of specifics as one moves toward the overall universe of discourse, which will include them all. At this point, the structure may be depicted as a triangle, with the most general principle or universe of discourse at the apex, and the most specific elements arrayed across the base. Intermediate levels will be composed of statements or concepts which include part but not all of these elements.

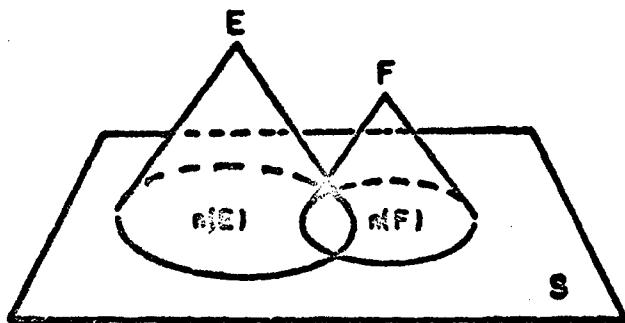


E AND F ARE SETS WITHIN SAMPLE SPACE S.
E ∩ F ARE THOSE ELEMENTS OF S WHICH
ARE IN BOTH "E" AND "F". (INTERSECTION)

Figure 3. Venn Diagram

An illustration of this premise may be drawn from the Theory of Sets by taking Venn diagrams as representing one level of abstraction while at the same time implying several more general levels. (Figure 3) The elements within a given sample space are the lowest or least general; for operational purposes, they are defined as indivisible entities. The total set of all these elements (Ω) is the highest or most general, defining the entire sample space or universe of discourse. Subsets, sets

and unions included in the sample space Omega all refer to intermediate levels in order of increasing generality.



E IS THE SET OF n(E) ELEMENTS
F IS THE SET OF n(F) ELEMENTS

Figure 4. Venn Diagram, Extended

Essentially, what we have done in Figure 4 is to extend the Venn diagram of Figure 3 into three dimensions, so as to depict the increasing generality. Each horizontal section now represents a plane of numerically countable entities at one level of abstraction. If, for instance, the universe of discourse is the set of all human beings, its elements will be individual human beings. Intermediate subsets, sets and unions will be families, cliques, interest groups, factions, parties, nations, blocs, etc., ranked along the vertical dimension of abstraction according to the relative number of these elements each includes. Exclusive or disjoint sets will be those to which no elements can simultaneously belong. In the human example, such exclusive sets would be those groups having as a membership requirement nonmembership in another specified group. One man cannot simultaneously be a Christian and a Moslem.

If one wishes to compare entities at dissimilar levels of abstraction, he will have to reduce both to their lowest common denominator or comparable level of abstraction.

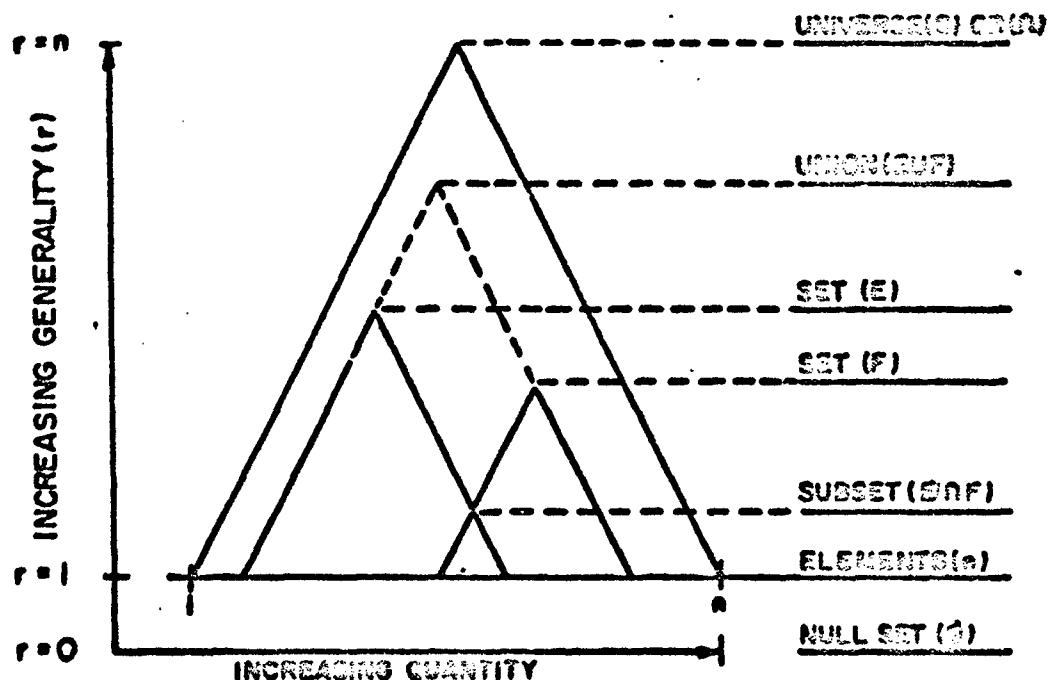


Figure 5. Nested Triangles

In Figure 3, both dimensions used to define the original sample space were numerically countable quantities. In Figure 4, the dimension of abstraction has been added. Since the multiple of two countable quantities is also a countable quantity, one of the two original dimensions is redundant. Thus, Figure 5 shows only the two dimensions of numerical quantity (horizontal) and abstraction or generality (vertical). The reason

these two dimensions have been drawn of equal length for any given set is based on the formula for combinations:

$$\binom{n}{r} = \frac{n!}{r!(n-r)!}$$

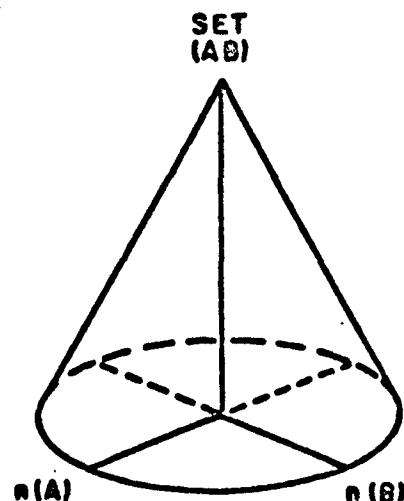
Here, n is the total number of elements included in the universe of discourse (quantity), and r is the number of elements included in each set (generality). As shown in Figure 5, r corresponds to the vertical dimension because increasing the number of elements included per set will simultaneously increase its generality.

At the level where $r = n$, we find the total set of all elements, or Omega. At the level where $r = 1$, we find the operationally defined indivisible (unitary) elements. It should be noted that the null set (\emptyset) falls within this portrayal as a level of abstraction below $r = 1$, where $r = 0$. Thus, the interval $r = 0$ to $r = 1$ includes all possible divisions of the initial elements, as the interval $r = 1$ to $r = n$ includes all possible combinations of the same elements.

According to the formula for combinations, levels of abstraction between $r = 1$ and $r = n$ may include more identifiable sets than there are elements. This is because each element is used many times in various combinations. But because the number of elements taken in any one set cannot exceed the total number of elements available (n), the two dimensions $r = 1$ to $r = n$ (generality) and $r = 1$ to n (quantity) are shown of equal length.

In pointing out that entities (sets) at dissimilar levels of abstraction may only be compared by reducing them to their lowest common denominator, it may now be seen that "lowest common denominator" refers to the lowest common level of abstraction or the point at which $r = 1$ for all sets to be compared.

At this point, the discussion might be described in terms of a series of nested triangles, because we have considered only identical elements. Where two or more kinds of elements are included in one universe of discourse, the relationship between these differing kinds of elements may be described by multiple axes in the vertical plane. Totally independent elements included in one universe of discourse may be indicated by orthogonal axes as shown in Figure 6.



**n(A) AND n(B) ARE MUTUALLY INDEPENDENT,
DISJOINT SETS PLOTTED ALONG ORTHOGONAL
AXES, BUT INCLUDED IN THE MORE GENERAL
SET(AB).**

Figure 6. Cone

While all axes in the vertical plane represent numerically countable quantities as they did in the original Venn diagram, such axes are now independent kinds of elements, rather than redundant enumeration of the same kind. This third dimension, which returns the depiction to conical rather than triangular, completes the major epistemological premise of

this study; that human knowledge is organized conically within the dimensions of (1) abstraction (vertical), (2) enumeration (horizontal) and (3) correlation (vectoral), where the vectors have numerical length and an orientation measured by angles in the horizontal dimension produced by vertical sections. Correlation between types of elements may vary from identity (+1 or 0°), through independence (0 or 90°), to opposition (-1 or 180°).

References, implications and applications of conical epistemology will be found throughout the following sections of this study. Further support for the premise may be found in the works of Beller, Braybrooke, Helmer, Hample, Jestice, Kaplan, Magee, Northrop, Polya, Rudner, de Chardin, Tricker, and others in the bibliography. Specific references are not given here because the premise is based on a synthesis of implications rather than direct quotation from any of the authors. Additional illustration of conical epistemology can be seen in any decision tree diagram, which will represent one vertical section through the cone. Each level of such a decision or relevance tree will contain a larger number of less general concepts as the tree expands. A more sophisticated version is Honeywell's computer program, PATTERN, which is structured as just such a conical series of stacked vectoral planes as herein described.

(Ref 8)

a. Continuum of Abstraction and Enumeration are implied by the premise of conical organization. This is because the two dimensions are common to all bodies of organized knowledge. Thus, abstraction in any body of knowledge is a dimension parallel to abstraction in all bodies of knowledge, and enumeration in one body of knowledge is measured along the dimension of number found in all bodies of knowledge.

In regard to the continuum of abstraction common to all bodies of knowledge, we find that the level which one assumes as unity ($r = 1$),

and to which he then applies enumeration, is itself arbitrary. The level of abstraction employed determines the definition of indivisible entities, but is entirely dependent on the interest of the operator and the problem at hand. As Allport states it:

Any 'entity' or 'thing,' at whatever level we find it, always seems to break down into a collectivity at a lower level. Our concepts of 'agent' and 'entity,' yes, even of 'thing' and 'particle' are tentative in character. They are singularities (entities) only at a given order. (Ref 9)

The arbitrary definition of indivisible entities has considerable impact on forecasting. What we assume as entity or actor will set limits to our reasoning and thus to our forecasting. Overly abstract definition will hide the composition and interrelationships within entities, as forecasting entirely on the basis of 'nation-state actors' leaves no room to consider factions, processes and conflicts internal to those actors. Overly specific definition follows the implications of conical organization by leading to ever-increasing volumes of detail, as seen in world-wide projections which attempt to include the impact of all factions and interest groups internal to the nation-state actors. Thus, selection of an optimum level of abstraction is an important step in the initial preparation of any forecast, and depends on the purpose for which it is designed.

b. Departmentalization. A second implication is that any set of principles may appear to define a separate and distinct body of knowledge, depending on the level of abstraction being utilized. (Ref 10) Such division of knowledge into tight and exclusive compartments also limits our reasoning. It leads to duplication of effort, under differing titles, and sets the stage for many problems including those of realm, semantics and relevance. The history of science holds many examples of such departmental barriers, and the requirements for overcoming them. In conical terms, departmental lines are amenable to study of elements

held in common by two or more frames of reference, and to definition of a more general set based on those elements. Current efforts toward integration of the social sciences on the basis of commonality are indicative of an early stage in this process. The discipline of Physics is an example of the product: by their greater generality, Newton's laws showed the formerly exclusive concepts of astronomy and mechanics to be subsets of one universe of discourse. Maxwell and Planck resolved the departmentalization of wave and particle theories by definition of the more general concepts of field theory and quantum mechanics.

c. Specialization/Generalization. The overall implication of conical organization is the farther one moves into abstraction, the fewer number of divisions he will have to consider, but the more complex each of these divisions will become. This is the context of the generalist or "breadth man." He knows a little about a large number of things. In the opposite direction we find the specialist or "depth man," who limits his universe of discourse to a very small subset in order to understand a few things more accurately.

A good bit of the friction and loss of efficiency in forecasting, academia and society in general stems from scorn of others' efforts on the basis of their being more generalized or specialized than our own. When one considers both "breadth" and "depth" studies in the same context, he finds them to be mutually interdependent. The generalist obtains his information by studying the reports of a large number of specialists. If he neglects to do so, and tries to learn everything for himself, he winds up speculating from an inadequate base. On the other hand, the specialist may come up with major insights in his own area, but these are not very useful until synthesized into more general theory and applied more widely than his own area of expertise.

2. Generation of Knowledge: Induction (Figure 7)

If, as we have maintained, knowledge is organized conically, it is a legitimate question to ask where it comes from and how it got that way. Philosophers have also been arguing about this for a long time, but the argument becomes pertinent when one attempts to forecast the development of science and technology, which are both essentially learning processes. Science is systematized knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principles of what is being studied. Technology is applied science, practical knowledge, or the study of industrial arts. Both generate new knowledge, but of slightly different sorts.

Induction is usually defined as: reasoning from particular facts or observations to general conclusions. This describes its vertical movement in conical terms, but only one of its characteristics. Intuition has been referred to as "subconscious induction," and some forms of meditation, contemplation and introspection have been given as synonyms. Perhaps the simplest form of induction is that performed by a young child as he first begins to learn.

a. Observation is the first stage of induction. It has several components; stimuli or signals, sensitive receptors, and attention. It is a selective process wherein stimuli are admitted or excluded according to the characteristics of available sensors. Here, the term sensors refers to a class or organs or instruments, of which the human senses are specific cases.

Structural limitations of the human senses have provided motivation for expanding the class of sensors. For instance, we do not receive certain frequency ranges because they lie outside the band-passes of our senses. We have overcome this limitation to some degree by evolving various external sensor/transducers -- like the radio -- to convert these

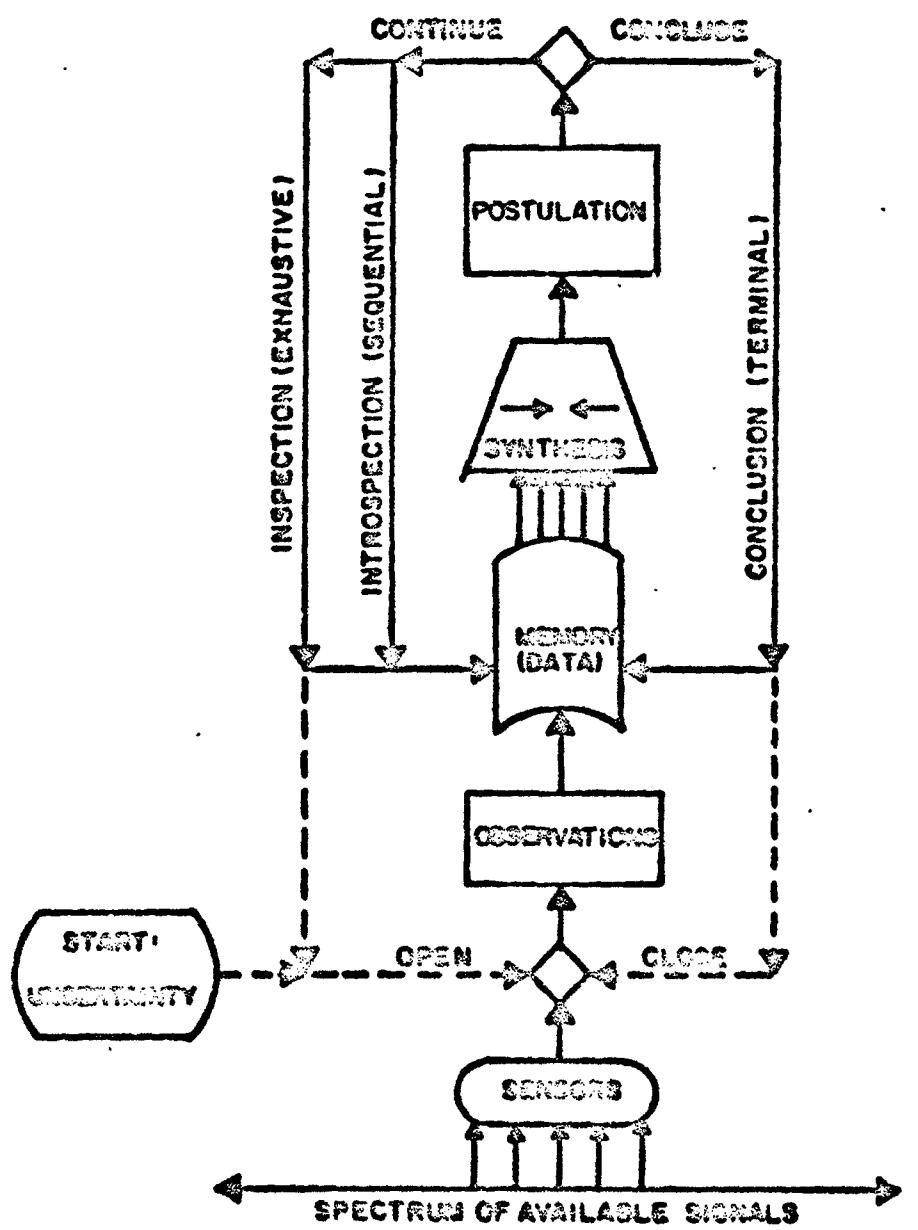


Figure 7. Induction

extrasensory signals into those such as visual and audial, for which we do have sensitive band-passes.

Other instruments such as the microscope, telescope, and telephone have been developed to extend our sensory capabilities in range, clarity and discrimination. All of these serve to increase our powers of observation and thus make more data available for the inductive process. We do not, however, have either senses or instruments able to extend our observations to future time.

b. Memory is the accumulator of observations. The memory function also has many parallels, from the information stored minute by minute in the individual mind to the written records of cultural memory and the magnetic storage drums of a computer. This accumulating function is necessary because signals are received sequentially in time, and have little meaning if taken individually. When stored or retained, these signals accumulate and provide the initial data base for induction.

c. Synthesis is the horizontal component of induction. Its action is to compare, correlate, combine, cluster, and so assemble the stored signals into sets, sets into classes, etc. As it progresses, synthesis makes fewer but more complex sets or clusters from a larger number of less general elements. It may appear to make a larger number of sets than it has elements of data only if each element is used many times in different combinations.

Synthesis acts to simplify by abstraction: convergence in the horizontal plane is accompanied by movement toward the apex. Its use is indicated whenever one has a large number of pieces, elements or events whose relationship is unknown. It is a difficult process, since to correlate a body of entirely unstructured data, every element must be compared with every other element, perhaps several times. The brute labor required has been a detriment in all areas of inquiry. Kepler worked at it

for about five years before he saw the pattern of an elliptical orbit in his planetary motion data. (Ref 11) Synthesizing computer programs have been a great need, and only a recent development. They hold great promise and wider application is indicated. Multivariate factor analysis, regression analysis, and cluster analysis are examples of such synthesizing programs. "Pattern recognition" is a general term which more adequately defines this class of techniques.

d. Postulation is the vertical component of induction; the recognition, identification, or labelling of a set of stimuli assembled by synthesis. Synthesis does not of itself create new concepts, but merely suggests them. The new and more general concept is created in the mind; this is the so-called "inductive leap." It assigns an identity or unity to the set or class as a whole. Thus, even "specific facts," data elements, and all concepts of unity or entity are initially creations of the human mind, postulated from the suggestions of synthesized stimuli.

Although sequentially equivalent to a conclusion, the product of induction is very seldom absolutely certain. The sensors do not admit all possible signals, and they tend to distort what they do admit. Memory is less than perfect, so some of the signals are lost. Synthesis operates by similarities and commonalities, which may or may not be precise. And postulation is the statement of one or more tentative hypotheses, by which the observed pattern may be identified. In the process of induction, the "conclusions" are not necessary consequents of the stimuli or the data employed.

e. An Operational Choice follows each postulation. As soon as a pattern of stimuli has been identified as a set, the operator faces a choice as to whether he will continue or conclude. If he elects to conclude, the identified set will become a unitary element, and included in his store of knowledge. He may then discontinue observation, since he has identified the fact.

If he elects to continue, he may do so in two ways; the initial postulate may be held aside and further synthesis accomplished at the same level. This is exhaustive synthesis. Its limits are predefined by the amount of stimuli he has stored at any one point in time, and by the rate of intake and storage over time. This is why a child learns as he accumulates stimuli, and why a more diverse environment will allow more learning; both time and diversity make more stimuli available.

Once two or more such sets have been postulated, he may elect to move to a higher order synthesis, by correlating them with each other. The result will be another postulate of higher abstraction, which identifies a unit composed of these two or more sets. This is sequential synthesis, which describes the inductive mode. It is a recurrent "bringing in," organizing and integrating of outlying stimuli, sets and classes. The stages of observation, memory, synthesis and postulation are repeated again and again, with the earlier postulates becoming the later elements. Except for the initial sensory stimuli, all of the more general levels are created in the mind.

4. Characteristics of Induction

(1) The primary requirement of induction is the assumption or attitude of uncertainty. This is because observation requires attention, and attention is likely to be removed from the already known. Synthesis also operates by asking questions; "What is the pattern; what is its meaning; what is its value?" "How is set x like set y?" All questions are a symptom of uncertainty; thus, it is in and by uncertainty that induction operates.

(2) Induction is seldom able to produce valid certainties. Except for the rare case where every possible element has been observed and correlated, inductive postulates are based on partial observations or samples, but assumed to apply to the remainder of the set or class as well.

(3) Generalization is the purpose of induction, but over-generalization is its primary fallacy. The few cases where a generalization can be made with certainty are relatively useless, because they only tell us about things we have already observed. They do not allow us to reason from the observed to the as-yet unobserved or unknown. On the other hand, a postulate based on an extremely limited sample and then extended to account for a much larger set of unobserved elements is over-generalized and very apt to be in error. Whether or not it is in error -- that is, the quality of knowledge -- is not determined by the inductive mode.

(4) Certitude is a fallacy which limits induction. Stating a conclusion in absolute terms is a fallacy in induction, because it removes the uncertainty by which the mode operates. Induction is inherently an endless process, but certitude halts it by making it seem unnecessary. In this context, certitude might be called the "Eureka fallacy;" "I have found it! (So I need look no further.)"

(5) Ignorance is a condition which limits induction. Ignorance is here seen as a lack of data, stimuli, observations, etc. Since these are the basic inputs to the process, once they are cut off or exhausted, sequential synthesis through introspection of data already in store has a finite limit. When all available data are correlated and organized, only further observation will allow induction to continue.

(6) Induction requires creative imagination on the part of its operators. This characteristic distinguishes it from all other forms of reasoning, and is also why the scientific or technological "breakthrough" is so hard to forecast. If one person could project what another will imaginatively create, the forecaster would have already accomplished the act of creation. (Ref 12) It would appear more possible to forecast areas, subjects and disciplines in which breakthrough may be expected, on the basis of amount of interest and potential for support from

other areas. (Ref 13) It does not appear possible to forecast the creation of a specific concept without actually creating it in the process.

(7) Induction builds conceptual tools without solving immediate problems. The latter is only done by application of those tools through deduction. Forecasting is no exception to this rule. Induction may form one stage of a forecasting methodology, and is the means by which concepts are created for forecasting in any event, but induction itself does not deal with future time. This is because the future has not yet presented stimuli, data or observable evidence from which general principles may be induced. Neither does induction reason from past to future events, as from known to unknown. What it does is to create a conception of the principle or pattern of change in past and present observations, from which the future condition may be deduced.

This is an important distinction, because it identifies one of the most serious difficulties in forecasting. In the quantitative approach as well as in subjective intuition, one of the primary tools is extrapolation. Extrapolation of trends is incapable of predetermining an inflection point or discontinuity because evidence of change in the trend has not yet been presented in the inductive base. Even in those cases where hypotheses of trend are updated by frequent observations, change of trend must actually have taken place before new data can alert forecasters to the unreliability of their assumed function. When frequent observations are not taken, inflections may be long past and come as a distinct shock when finally discovered. This is far from optimum forecasting.

The same considerations also limit forecasting by analogy, but to a somewhat lesser extent. The limitation comes through insufficient inductive study of current symptoms to determine if an analogy with recognized patterns is justified. When symptoms are merely scanned and the hypothesis of analogy over-quickly postulated and assumed for projection, forecasts based on the analogy are also apt to be irrelevant.

(8) Each level of induction must operationally assume the validity of its data base. Even though the postulates of each level are actually tentative, in order to move to a higher level, they must be taken as fact. The effect of this characteristic is to reduce the certainty of a postulate by the combined uncertainty of the data on which it is based. Thus, as induction continues through several levels of abstraction, its certainty is progressively reduced. This is why "specifics" are seen as more likely to be "facts" than are "generalities." The more abstract, the less likely a concept is to be certain.

(9) Induction cannot operate on simple dichotomies.* "Either/or" is the logic of discrimination; it is useful for finding the limits of sets, but not their correlation. When used for synthesis, two-valued logic will produce only inclusive or exclusive sets -- classifications -- which are determined by relating the observation to an a priori set of criteria. Two-valued logic follows the "law of the excluded middle;" (Ref 14) it is appropriate for deduction because it implies certainty (it is or it is not), but it is not appropriate for induction for exactly the same reason. The "middle" which two-valued logic excludes is the uncertainty interval, and it is uncertainty by which induction operates.

Thus, we find induction to be the building or growth mode of organized knowledge. Its conclusions are general and do not answer specific questions directly. They are never certain and never complete. The process is difficult, requires uncertainty and a particular type of creative imagination on the part of its operators. It is also slow and it moves in not entirely predictable jumps. However, it is the process by which knowledge

*It should be noted that the term "simple dichotomies" does not refer to the "binary system," which is capable of high mathematical sophistication, but of one form of simplification by opposition.

originates and becomes organized, the logic of basic researchers, inquisitive children and the acquisition of experience.

3. Application of Knowledge: Deduction (Figure 8)

Deduction is usually defined as reasoning from a known principle to an unknown, from the general to the specific, or from a premise to a logical conclusion. Here, "logical conclusion" means "formally consistent." Deduction is the reasoning of formal logic, which deals only with the form and not with the content of the process. Most of the so-called "logics" or "systems of logic" are actually variations of this mode. In practical application it also has a large number of functional equivalents; selection, analysis, discrimination, decision and projection -- to mention only a few.

a. Assumption is the initial stage of deductive reasoning. This is a selection of concepts from those available (including concepts in regard to rates or patterns of change), and the statement of these concepts as matters of fact. Thus, the primary but implicit assumption of all deductive reasoning is that of certainty. "Reasoning from the known" actually means "reasoning from that which is assumed to be certain." This is the operational assumption of the mode. It is also why formal logic can afford to ignore the content and to concentrate on the form of the argument; the content does not really matter because it must be assumed as certain from the outset, no matter what it is. Nonsense statements and purely abstract symbols may serve formal logic as well as any other statements.

b. Analysis is the horizontal component of deduction. It acts to separate, discriminate, distinguish and so divide classes into sets, sets into elements. This is usually done implicitly in the process of stating the premises. In formal syllogisms, each of the two premises contains two terms or assumed factual concepts, one of which is common

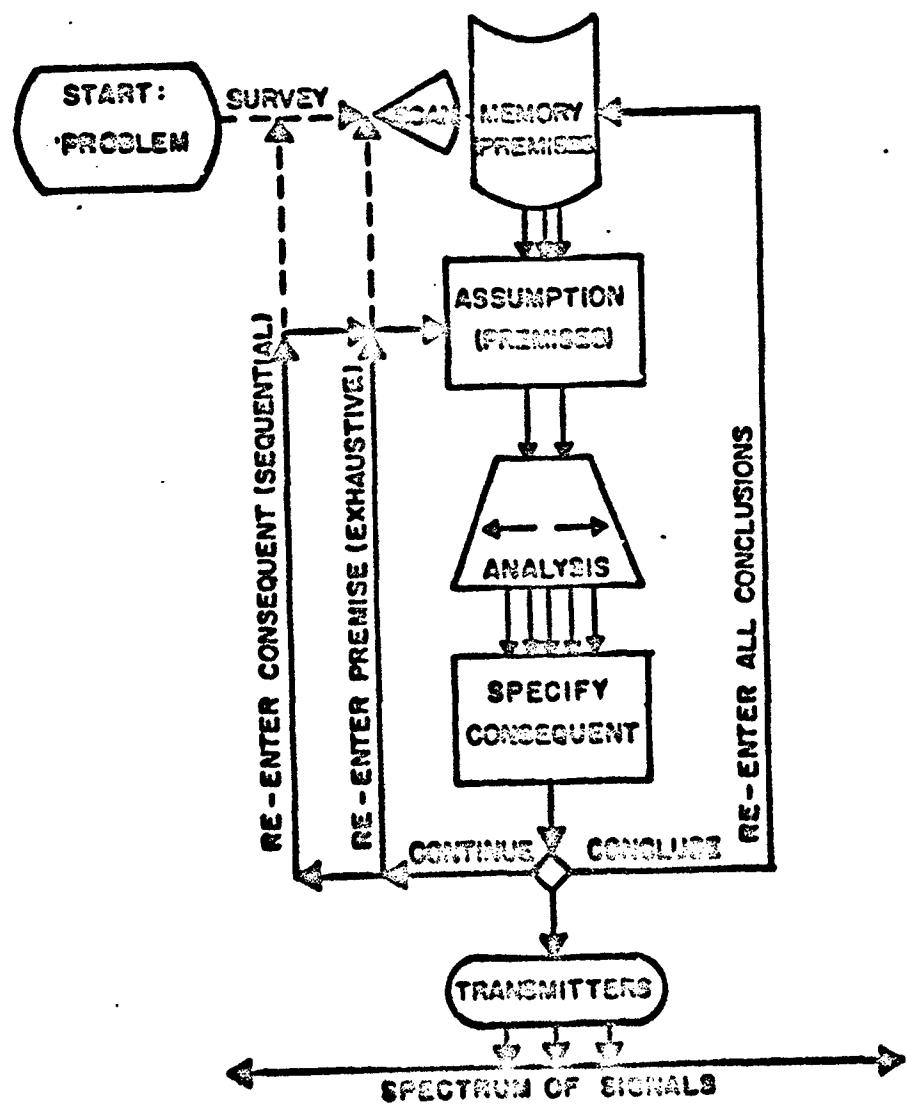


Figure 8. Deduction

to both premises, and must be stated as "all" or "none." (Ref 15) "All men are mortal" is a premise in which the set of "all men" is stated to be a subset of "mortal beings." The minor premise, "Socrates is a man" states that the entity or element "Socrates" is a member of the set of "all men."

At this point, the set of "mortal beings" has been analyzed and all mortal beings except men have been deducted or discarded. The set of all men has also been analyzed and all men except the one specified have been deducted. The only consistent consequent, "Socrates is a mortal," is already implicit and needs only to be stated. This is why deduction does not create new knowledge; all consistent conclusions are already implicit in the stating of premises.

c. Specification is the vertical component of deduction. As each premise removes from consideration all elements implied by one term but not also included in the other term, the movement is from the more general to the less general, or specific. Conical organization would indicate a movement from general to specific be coupled with expansion in number, which would be the case if analysis were used alone. Many researchers are familiar with the expansion characteristic of analysis, whereby any concept may be divided into an unmanageable volume of details. Deduction, by removing details from each concept or term, results in a conclusion more specific than any of them. The geometry of such an operation may be described as a downwardly-narrowing cone focused on specific conclusions, but entirely contained within the upwardly-narrowing cones implied by the terms employed.

d. An Operational Choice follows each analysis/specification stage. Each of these stages (syllogisms) is limited by the level of abstraction fixed in defining the "indivisible" elements. (Ref 16) In practice, these limits are often broader than the problem at hand.

Thus, the choice is between analyzing one level to exhaustion, or reentering the specified consequent as a premise for sequential operation. Such deductive trees as PATTERN employ exhaustive analysis at each level, drop out less relevant subsets, and then proceed sequentially to the next lower level.

e. Conclusions by deduction may occur at any level below that of the most general term, depending on the problem at hand, the interest and the patience of the operator. Since even the arbitrary "elements" or "indivisible entities" of the original stage may be selected as premises and divided by analysis, the lower limits of deduction are those of organized knowledge. Analysis and specification must cease only when the organization of the next lower level is unknown. In practice, deduction usually stops with a conclusion relevant to the problem at hand or the purpose for which it was undertaken. In any event, once the operator decides to conclude deduction, he also stops selecting further premises and the entire process terminates. It should be noted that deduction operates solely within the body or structure of existing knowledge.

f. Characteristics of Deduction

(1) The primary requirement of deduction is the attitude or assumption of certainty. With this assumption, it does not have to investigate the validity of its premises, but may merely assert what must follow if the premises are true.

This is at the same time the greatest strength and the greatest weakness of the mode. The strength is that conclusions will be true if the premises are true and the logic formally consistent. The weakness is that formal consistency may imply a true conclusion in cases where it is not justified.

(2) Conclusions must be necessary consequents of the premises employed. While there are dozens of identified fallacies in

formal logic, they may all be subsumed by this one criterion. Although there are actually three divisions of formal consistency -- consistent (called valid by some writers), fallacious, and indeterminate -- the latter two are usually lumped together because neither meets the prime criterion. Thus, conclusions are seen as either necessary or fallacious.

(3) Deduction operates on two-valued dichotomies. Because it utilizes statements of fact, and statements are a symptom of certainty, deduction may also employ two-valued logic. It follows the "law of the excluded middle," which was invented by Aristotle specifically for this purpose, to make the certainty of formal logic possible.

(4) Deduction does not create new knowledge, but through its analytic stage, it often does disclose otherwise unrecognized implications of its premises and their combinations. These may have the same effect as new knowledge. Many of the greatest discoveries have been made through analysis of the implications of laws, theories and hypotheses induced earlier, and much of the progress in technology occurs in this way. Although all possible forecasts are implicit in the premises employed, it is this characteristic of deduction which reveals their unforeseen implications and so makes foreknowledge possible.

(5) Deduction is limited only by the amount, the kind and the clarity of the premises available. Thus, ignorance is again a barrier, but in the form of nonavailable premises or general principles. The quality of knowledge is not a barrier to deduction, because it can operate equally well with nonsense statements, wild guesses, purely abstract symbols and scientific laws. The only useful point at which it may be questioned is the formal consistency of the argument itself. Once this has been established for a given argument, nothing further is to be gained in this area, and evaluation of reliability must shift to the validity of premises.

Because it is also deductive, the same characteristic is found in the projection stage of all forecasting methodologies. Formal consistency may raise the reliability of predictions up to -- but not beyond -- the validity of entering assumptions, while formal fallacies only serve to reduce reliability below that level.

Thus, we find deduction to be the application or use mode of organized knowledge. Its conclusions are specific; they answer questions and solve practical problems. It is also rapid, efficient and easy to follow; thus, it is the most effective mode for display and dissemination of ideas. Because most mathematical systems are built on its two major assumptions of certainty and consistency, it lends itself readily to mathematical and computerized sophistication. The characteristics of deduction are found in all of its many applications. In all of these it is the practical, immediate and confident mode by which organized knowledge is put to work to solve specific problems with the tools at hand, and without which most of organized knowledge would be useless.

4. Quality of Knowledge: Validation

In discussing the generation, organization and application of knowledge in terms of quantity and generality, the major question has not been addressed. The question pertains to the quality of knowledge, "Is it so?" Fantasy may be as well organized as fact, superstition as consistent as science. Forecasts may be produced from guesswork or laws. What distinguishes one from the other is the quality of knowledge. It has many synonyms, including: objective validity, empirical fact, actual knowledge, or simply, the truth. Our purpose in forecasting is not so much to increase the amount we know about the future, or the generality of our concepts, as it is to increase the accuracy or quality of foreknowledge. One accurate forecast is more valuable than many inaccurate speculations.

The terms reliability, power of prediction and subjective probability have been used to denote the ability of particular concepts to provide such high quality foreknowledge. This ability does not rest on how much is known, but on how well it is known. This is the context of validation. As pointed out, the two major processes of induction and deduction both reason from the known (or assumed known) to the unknown. Deduction assumes the validity of its premises, and induction assumes the validity of its data. Thus, the question of how to determine objective validity lies at the heart of reliable forecasting and the evaluation of forecasts.

However, establishment of objective validity is not a simple problem, nor is it of recent origin. In the larger context of philosophy, it forms the core of a persisting controversy that reaches back over centuries. Because of this controversy, many philosophers have referred to it as the problem of a "theory of knowledge," or "the problem of knowledge." Thus, the decision maker is in good company when he tries to figure out how much confidence to place in the forecast he has before him. The problem has now moved down from the ivory towers and onto the administrator's desk.

As seen in classical philosophy, the task of a theory of knowledge is to devise some criteria of validity, or first principles, which may then be applied to determine if any given statement is true or false. It is precisely this sort of criteria -- in the form of a checklist -- which the responsible decision maker and forecaster would like to have.

A great host of "universals," "absolutes," and "eternal principles" have been proposed and argued pro and con. However, some philosophers -- notably Kant and Hume -- have held that such a theory of knowledge is impossible, on the grounds that criteria of validity are themselves statements or concepts, and their own validity may only be ascertained through the fallacy of proving them by themselves. To date, it would

appear the sceptics have it; no one has been able to develop such a system of universal criteria of validity and successfully defend it. Thus, the "problem of knowledge" remains unsolved. Nor do we propose to solve it here. However, within the frame of reference of conical logic, we do find what may prove to be another line of attack on the more pragmatic aspects of the problem. We are more interested in providing some assistance to the forecaster and decision maker than in philosophical argument as such.

In general, there are two ways of establishing validity; submission to authority and submission to evidence. Both of these appear to be logical processes which combine the two basic modes of deduction and induction. Each will be discussed individually, in an effort to identify their typical strengths and weaknesses, and so where and how they may be applied for the improvement of forecasting.

a. Authentication (Figure 9)

The word "authentication" is not normally used in reference to a mode of reasoning, nor does it appear as such in the study of logic. It is so used in this study because it appears to describe the process underlying a set of problems observed both in forecasting and in the operation of organized knowledge in general. Thus, it is presented as a tentative hypothesis, drawn from the commonality of observations.

Authentication is defined as: that mode of reasoning which combines induction and deduction, and whereby new or recently acquired stimuli, observations, raw data, etc., are classified, coded, validated or otherwise interpreted by reference to previously organized knowledge, where such knowledge may appear in the form of axioms, or their embodiment in the opinions of authoritative persons.

Authentication, then, may either identify or validate observations by submission to authority. It may also be employed to assign values (good, bad) to such observations in the same manner.

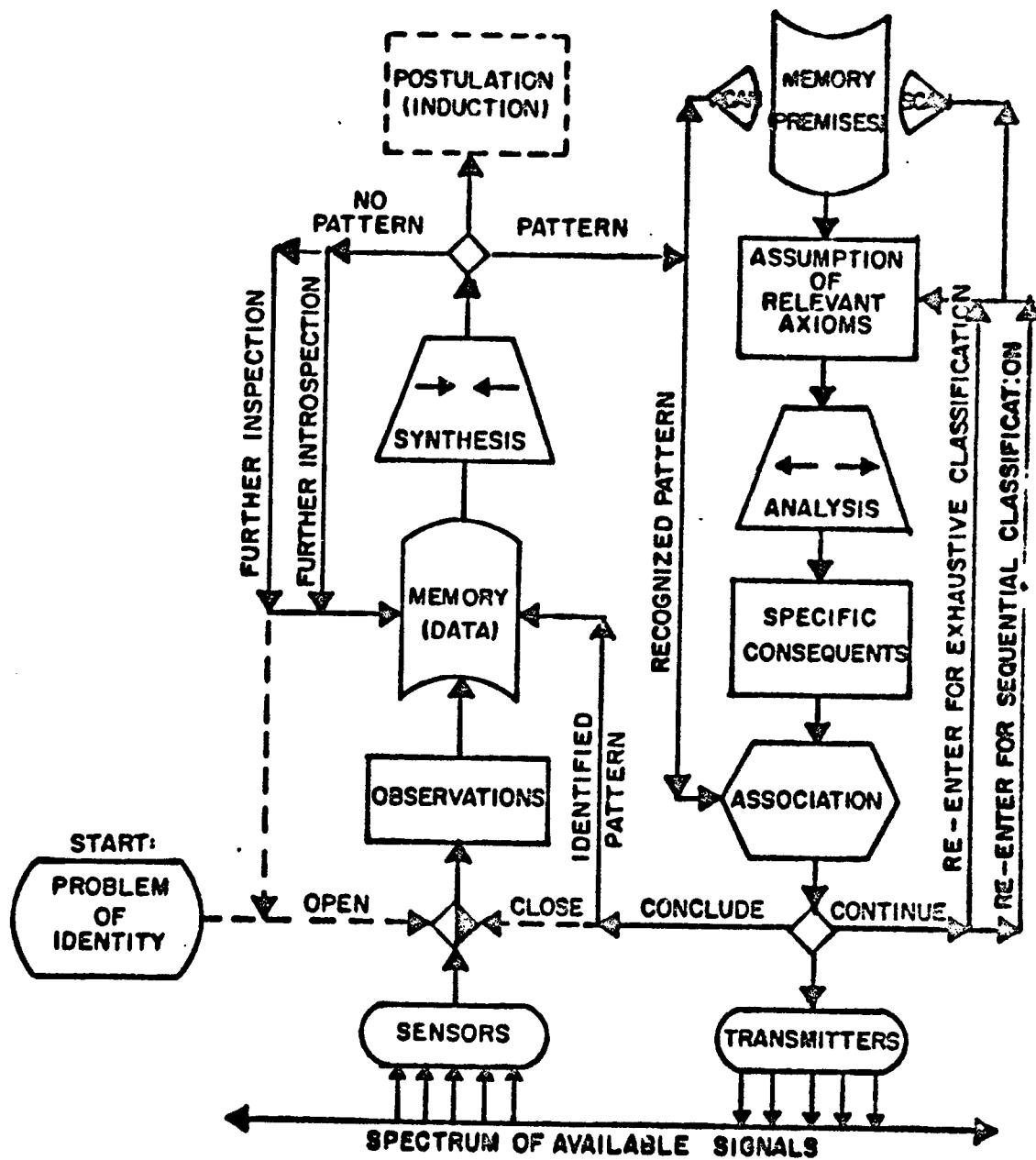


Figure 9. Authentication (rational validation)

(1) Induction forms the initial stage of this process. Raw data or observations are collected and synthesized to the point where a pattern is seen to exist. At this point, the pattern has little or no meaning. It may obtain meaning only by postulation or association. To obtain meaning by postulation would complete the inductive process; to obtain meaning by association transforms the process to authentication. In logic, such a shift is called traduction.

(2) Deduction is the second and the dominant stage of the process. The pattern recognized by induction is taken as a criterion of relevance and used to search the immediately available memory for a relevant axiom or value. If no relevant axioms are found among local resources, the search may expand to any other sources, including other persons, agencies, libraries, and so forth. In this way, stimuli and raw data gathered by one operator may be authenticated by axioms from another.

In the deductive stage, axioms located either internally or externally are analyzed to their specific consequents, which form the second input to the next stage.

(3) Association matches the pattern recognized by induction with the specific consequents of relevant axioms. The consequents of the axioms are taken as authoritative, and used to identify, classify, evaluate or validate the inductive pattern. Deduction is dominant because only the relevance and not the validity of the axioms or their consequents may be questioned.

(4) Conclusions reached by authentication are essentially labels. They state what the recognized pattern is or is not, whether it is true or false, good or bad. The raw data are now coded by reference to prior knowledge; they have obtained meaning and may be included in the receiving body of knowledge. Where it is used for identification,

conclusions are called perceptions. When it is used to decide if something observed is true or false, the result is validation by submission to authority. And when axioms of value are applied, the process is evaluation and the conclusions are assigned values. The specific conclusions reached by any of these parallel processes will vary according to the set of axioms employed. Thus, the same stimuli or observations may be identified, interpreted, validated or evaluated in entirely different ways when different axioms are used.

(5) Characteristics of Authentication are as follows: (1) It does not create new knowledge, but rather transfers meaning from the already known to the newly observed. (2) Observations made by one person or actor may be authenticated by axioms from another; thus, the organizational pattern is transmitted from one specific store of knowledge to another and so preserved over time. (3) It does not actually establish the validity of observations or assumptions, but merely moves the problem one level into abstraction; the verity of the axioms must either be taken on faith, or the axioms themselves submitted to empirical evidence. (4) It does establish the identity and meaning of stimuli and raw data observations. (5) Conclusions reached from identical observations will differ to the point of contradiction, depending on the axioms used for authentication, because the conclusions are consequents of the axioms rather than of the observations. (6) Conclusions reached by authentication, like those of deduction, imply certainty or authority whether or not this is justified.

(6) Implications of Authentication are found throughout forecasting. They are best seen in the formation of analogies. This is the reasoning whereby observations of current symptoms are identified as precursors of patterns recognized in the past.

We also find it in quantitative extrapolation and assignment of probabilities. There is no functional difference between forecasting by historical analogy and the "legislation" of a curve. Both study the patterns of observed data, and match these with a preconceived function (hypothesis of variation). It is this hypothesis, rather than the observations, which is actually projected. Both have the advantage of employing an existing hypothesis rather than having to invent one, and both have the problem of hasty or irrelevant analogy. Both also imply a certainty they may not in fact possess.

The same considerations apply to the assignment of 0 to 1 scales and the computation of statistical probabilities. The 0 to 1 scale is very handy; perhaps exceedingly so. The ability to compute statistical probabilities for future events is an accomplishment much to be desired. But such rigor must be built from the bottom up; it cannot be attained by fiat, by lumping data together without respect for dimensionality, comparability and measurability, arbitrary legislation of 0 to 1 scaling, and computation of probabilities to high decimal orders. The drawing of analogies between celestial mechanics and human affairs (astrology) is no more risky and may be far more rigorous.

A similar problem is observed in attempts to quantify matters of value, cost, risk, utility, etc. Observations of variation in many areas are encoded for mathematical treatment solely by an arbitrary legislation of dollar equivalents. This shows the use of authentication as it applies to values.

In all of its many applications, authentication has one characteristic strength and one typical weakness. The strength lies in its ability to transfer accumulated knowledge from one memory to another, thus making it available for wider application. The weakness lies in its tendency to assign confidence or authority to axioms or persons whose

opinions are considered axiomatic where this is not justified. In all cases, the authority of these axioms must either be tested against further evidence, or simply taken on faith. In forecasting, there is considerable evidence of failures due to taking authorities on faith alone. (Ref 17)

On the positive side, authentication is vital when applied with an awareness of its hazards. Because its conclusions imply authority, and because observations by one source may be organized by experience of another, authentication is the logic of borrowed learning, formal and informal instruction, indoctrination and enculturation. The "collation of validators" in any store of knowledge -- personal, professional, cultural, national or ideological -- will be seen as a set of authoritative axioms or "self-evident truths." They are employed to identify, interpret, validate or evaluate a large portion of all observations; thus, authentication is the primary channel for the continued existence of both the axioms and the corporate entities which they define. The common application of this mode has led philosophers to the doctrine that ideas have their own independent existence. Without it, every human being would have to learn all he knows by laborious induction from his own limited observations, and so would be forced to reinvent the stored knowledge of the race. Thus, authentication is the mode of reasoning which provides the intake side of organized knowledge transfer, as deduction provides the output. Together, these two modes form the rational branch of reasoning.

b. Verification (Figure 10)

Verification is the mode of reasoning specifically concerned with the quality of knowledge. It is the logic of submission to evidence, testing, simulation and experiment. It is often called "empirical validation," as opposed to submission to authority, which is rational validation. Like submission to authority, it combines both inductive and deductive stages; however, the sequence of their operation is reversed.

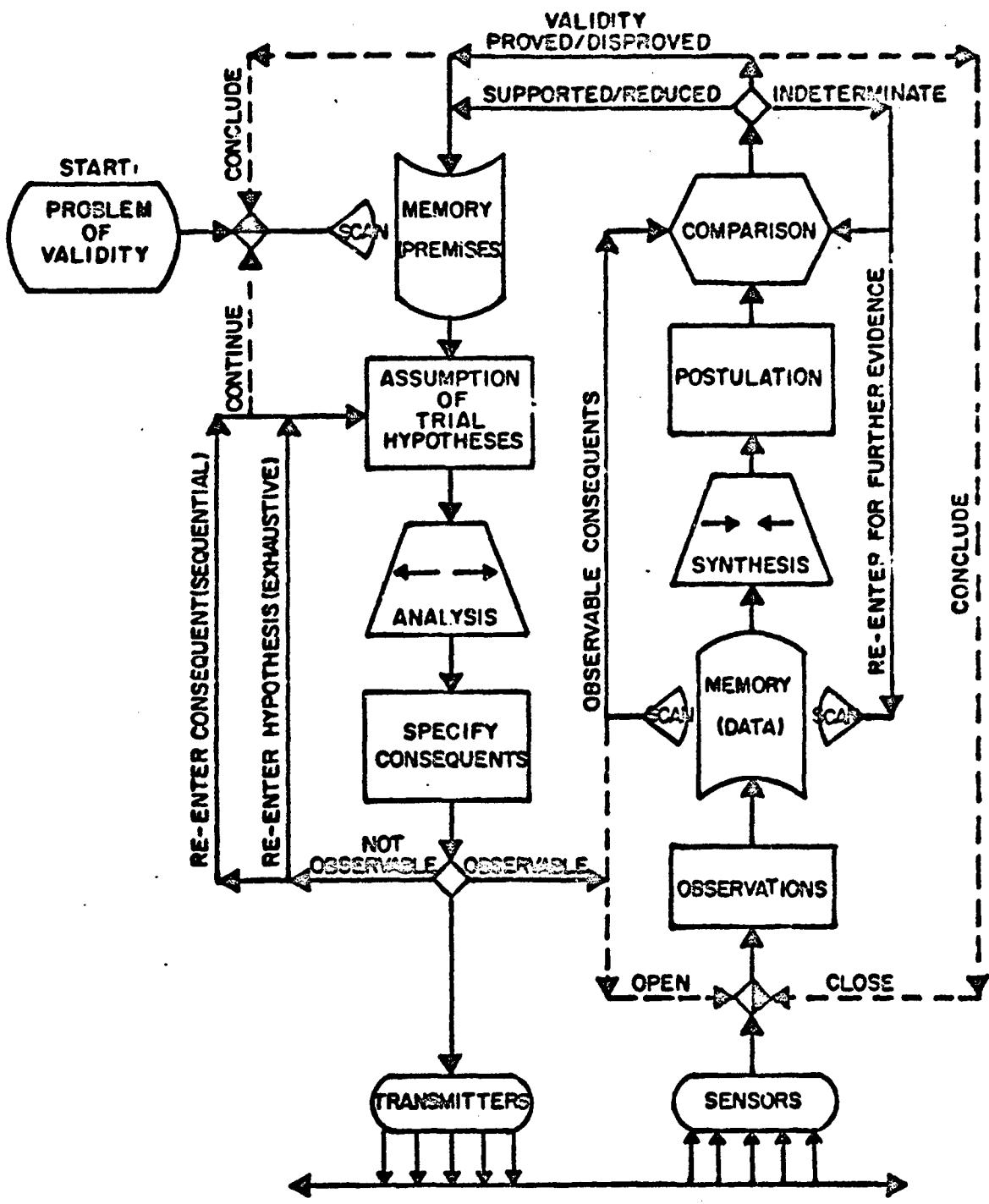


Figure 10. Verification (empirical validation)

(1) Deduction is the first stage. A premise is selected or assumed; however it is not considered to be valid or authoritative. This is because the purpose of the operation is also reversed; rather than serving as the source of validity, the premise itself is now in question. The only difference between an axiom and a trial hypothesis is the amount of confidence someone has in its validity. Thus, the same statement which is employed as an authoritative axiom for deduction or authentication may also be taken as a trial hypothesis for verification. The one essential prerequisite of this mode is the assumption of uncertainty, the willingness to challenge and test an axiom as though it were merely a trial hypothesis.

In some cases a trial hypothesis will refer to phenomena which are directly observable. In many cases, however, some consideration such as distance, abstraction, risk, or location in time, will make direct observation either impossible or unwise. In these cases, the premise must be analyzed and the criterion of observability employed to select from its necessary consequents those which are at least potentially observable. These necessary and observable consequents are then stated as specific projections or predictions.

Such projected assertions must be carefully and clearly stated, so as to define the conditions to which they apply and the evidence which will constitute affirmation or denial. Any assertion so vague as to leave large questions as to the evidence necessary to affirm or deny it cannot be verified. Ambiguous statements which allow two contradictory interpretations must be differentiated into separate assertions before either can be verified, since they may call for differing evidence. And cases in which alternate or competing hypotheses propose to explain the same phenomena will have to be submitted to the same evidence in order to decide between them. Thus, lacking a universal theory of knowledge with

its absolute criteria of validity, the criteria of verification must be included in each statement to be tested.

(2) Induction is the second stage. The observable consequents are taken as criteria of relevance for the sampling or observation of evidence. These then establish a data base relevant to, but derived independently from the original hypothesis. If the test base is not relevant, the evidence is useless; if it is not derived independently, the test is biased, and if it is not sufficient, the test is indeterminate.

Once observations are made, they are taken as authoritative. This is because, like induction, verification must assume the validity of its data base. Evidence is collected and synthesized to the point of pattern recognition. This completes the inductive stage.

(3) Comparison is the final stage. The pattern recognized from the collected and synthesized evidence is matched with the projection made earlier. This is similar to the association stage of authentication, but the purpose is again reversed. Instead of using the hypothesis or its necessary consequents to test the pattern recognized in the data, the pattern recognized in the data is used to test and support or deny the hypothesis.

(4) Conclusions reached by verification are specific, but they do not imply certainty for several reasons. (1) The premise is tentative rather than authoritative. (2) Only that portion of the premise's implications which were observable are actually tested. (3) The authoritative evidence is derived by induction, and induction is incapable of attaining certainty except when all possible evidence is sampled. (4) The operational assumption of this mode is that confirmation or denial of specific consequents also implies affirmation or denial of the premise. In deduction, this would be considered the fallacy of affirming the consequent. (Ref 18) It is a fallacy in deduction, because it is incapable of

producing certainty. In verification it is not fallacy, but a necessary procedure. (5) No amount of evidence can guarantee that the next observation will not absolutely deny both the consequent and the premise. For these reasons, no validation is ever certain. This characteristic it shares with induction.

(5) Requirements of Verification are as follows: (1) The initial assumption of uncertainty, (2) observable consequents of the hypothesis to be tested, (3) adequate definition, (4) available evidence which is relevant, sufficient, free of bias, and accurate. Lacking the initial assumption, verification is impossible. It is also impossible to verify something which cannot be observed; however, observational capabilities may be expanded by technology, and even nonobservables may cause observable effects which can be used. Inadequate definition and lack of evidence make any verification indeterminate.

(6) Implications for Forecasting. Verification is the only mode of reasoning designed to couple assumptions and hypothetical constructs to dispassionate reality. Except for our use of this mode either by specific design or accidentally through trial and error, there is little basis for believing any of our ideas correspond to reality. Since the purpose of forecasting is to increase our awareness of potential reality, and this is done by deduction which cannot test the validity of its own assumptions, invalid and indeterminate premises are useless for this purpose. The cost of error makes them of negative utility. Thus, verification -- empirical validation -- is the primary avenue for the improvement of forecasting.

Because verification is incapable of attaining certainty unless all possible evidence is in, and the evidence necessary to test the assumptions behind a forecast is not in until the time period of the forecast has expired, no forecast can be certain at the time it is made.

On the other hand, there is no other way by which the objective validity of assumptions -- and thus the power of prediction -- can be systematically and progressively increased. Verification is the logic of the sceptic, the doubter and the personally humble man who questions his own axioms. It is the experimental mode, the logic of systematically reduced uncertainty. Together with induction, which also operates in and by uncertainty, it forms the empirical branch of reasoning.

5. Problems of Mode

The four modes of reasoning are by no means exclusive or independent; however, at one time or another, each has been emphasized to the neglect of the others. Many "schools" of philosophy are identifiable on this basis. (Ref 19) So are the reasoning patterns typical of certain disciplines, professions and projects, including many now involved in forecasting. It is not surprising that individuals often prefer one mode above all others; each one is more appropriate for specific purposes. Difficulties are common, however, when logics are misapplied, and such misapplication forms one of the major barriers to forecasting.

While many value-judgments have been argued between advocates of particular modes, no such inference is intended here. Each has its own specific utility, depending on the nature of the problem at hand. This utility we would hope to illustrate as the indicated means of improving particular areas of forecasting.

a. Problem Recognition

In all areas of inquiry, the first problem is to recognize that a problem exists. (Ref 20) Such awareness may be obtained either through experience or interrogation. The former is rational or pragmatic; the latter is empirical or experimental.

(1) Rational Problem Recognition. When obtained through direct experience, the most common symptom of problem recognition is

surprise. A prediction does not correspond to subsequent observations, or an explanation is found to have been in error. The heuristic or "feed-back" function of forecasting has a long history of usefulness in this regard. When Kepler found the planet Mars to be eight minutes of arc away from his predicted location, he began to suspect a problem with his oval orbit theory. Much of modern physics owes a debt to Galileo's surprise when he noted that cannonballs did not behave as Aristotle's mechanics predicted they should.

Heuristic learning is a primary value of forecasts and a major reason for their construction. Every forecast that fails is potentially a source of information for recognition of error, provided the question "Why?" is asked and answered. Improvement of forecasting may be accomplished in this direction, and the patterns or commonalities of unsuccessful projections are a significant area for further studies. Lacking such efforts, an unsuccessful forecast has little value.

To the modern forecaster and decision maker, however, the pragmatic approach to problem identification -- try it and see if it works -- is not always cost-effective. Not for any lack of effectiveness, but because cost of error may be prohibitively high. This is especially true in long range forecasting, where the marginal utility of "wait and see" diminishes rapidly. Thus, the choice of means for problem recognition must be made on the criteria of criticality and range, i.e., the cost of error.

(2) Empirical Problem Recognition. In those cases where cost of error is high, interrogation is indicated. To become aware of problems through interrogation means that someone has to go looking for them. This is the "problem hunter," as opposed to the pragmatic "problem solver." It is also referred to as being "problem oriented," rather than "product oriented."

The two major barriers to effective forecasting -- ignorance and certitude -- are both reducible by problem orientation. Ignorance is "not knowing;" its primary symptom is lack of information. It may be reduced by directing questions at the fringes of knowledge; "What do we need to know?" "What don't we know?" Of the two, it is by far the easiest to deal with. Its utility lies in an increase of organized knowledge; its major mode is induction.

Certitude, on the other hand, is believing you do know. Lack of predictive power, competing theories, and inability to explain current phenomena or events are indications. Dogmatism is often another. Certitude may only be reduced by questions directed at the heart of knowledge; "Do we really know? How well do we know?" It is often more difficult, but is fundamental to all problems of validity.

In either case, the empirical approach demands we place ourselves into uncertainty. As Clerk Maxwell remarked, "We must pretend we do not know." (Ref 21) This is why we do not call this approach to problem recognition "Analysis of the problem," but rather "Interrogation." Analysis operates by statements of fact; interrogation operates by questions.

b. Problem Utilization

No matter by which of these means one becomes aware that a problem exists, his course of action will depend on how he utilizes this potentially valuable information. He may ignore it and continue as before. Here we have the old maxim, "Those who do not learn the lessons of history are doomed to repeat it." Or he may search for the expedient solution, and if he finds it, solve his problem through authentication. He may use either the problem or its subsets as selection criteria for methods and principles to be validated. Finally, he may select critical subsets as grounds for initiation of basic inductive inquiry.

In all of these uses, it is the original problem, task or purpose that sets the stage for selection of realm, logic mode, and level of abstraction. This in turn conditions the type of inputs required, likely sources of such inputs, the general procedure to be followed, typical fallacies to be wary of, and lastly, the sort of outputs to be expected and the kind of activity such outputs will support. All of these properties vary for each realm and each mode; misapplication can nearly always be guaranteed to produce unsatisfactory results in light of the intended purpose. Thus, it is with the nature of one's problem that inquiry must begin, and the nature of sequential or underlying problems by which it must be pursued. All we have at the beginning is the problem itself. It deserves considerable attention and interrogation before one turns to analysis of its subsets and consequents or search for solutions.

c. Selection of Mode

One set of criteria which may be drawn from interrogation of the problem is that of implied logic. This is of value in ascertaining the relevance of particular techniques, methods, principles, etc. These criteria center around the question: "Is this problem or subproblem basically rational or empirical?" The second order of questioning follows the four logic modes: "Is this rational problem best handled by deduction or authentication?" "Is this empirical problem one that indicates validation or induction?"

(1) Rational Problems are generally those which require rapid, precise and reliable answers. Decision making belongs to this class; so do such practical problems as driving a car, flying a plane, learning algebra, putting thoughts into words, or buying a house. The list is well-nigh endless -- from how to make a fire with flint and steel, to the optimum procedure for launching a spacecraft or planning an economy. They are all practical problems or problems of technology,

which is "practical knowledge" by definition. They indicate the application or acquisition of rules, laws, axioms, standard values, procedures or techniques.

The rational logics, deduction and authentication, are the most useful for day-to-day decisions, evaluations and operations. There is little utility in trying to reinvent a technique, concept or scale of values if one is already available or can be borrowed that will do the job and solve the problem at hand. Thus, where they are applicable, deduction and authentication should be the first choices among modes of reasoning.

(a) Deductive Problems are those which require application of an existing principle or concept for rapid and practical answers. Other problems calling for this mode are those in which a large or complex concept -- including large and complex problems -- must be broken down into specific components. System Analysis, Mission Analysis, and Operations Analysis are examples. Interrogation of the problem is a special case. While the structure or pattern of questioning is rational, the questions themselves are applications of uncertainty as a tool, and thus empirical.

Any problem requiring isolation of specifics is deductive, including sampling and the design of relevant but simplified models. Analysis of definitions and deduction from abstract concepts to measurable observables fall into this class. In general, the mode is indicated in any situation where something needs to be taken apart in order to "get down to cases."

Deduction is also the mode for projection, and has no substitute in this role. While a group of projections may be synthesized into a composite view of the future, the act of projecting each trend or analogy is still deduction over time. The future does not provide data for induction, evidence for validation, or either stimuli or principles for authentication.

While it does not provide principles for deduction either, the present does, and when these principles contain a time function, their deductive consequents are images of a future state or direction. It is to this extent alone that we can "know" the future. (Ref 22) Therefore, projection is essentially a rational problem, calling for the deductive mode. It is only when failure of projection is recognized by experience or identified as likely by interrogation that the nature of forecasting shifts into other modes of reasoning.

(b) Authentication Problems are those in which applicable -- practical or rational -- knowledge is required but not immediately available. In general, this class of problems may be identified by a need to acquire skills, facts, concepts, methods or operational techniques. With the criteria of relevance obtained from problem recognition as a guide, one begins to search for potential solutions. When his own experience or expertise shows no relevant methods, he moves progressively outward in range. The first place to look is, of course, in the office down the hall or to the books in the local library. Failing there, he moves to outside sources; cross department, or cross discipline.

The operational assumption is that the needed information is available somewhere, if it can be located. It is the second mode of reasoning in order of preference, because its utility lies in the fact that one does not have to duplicate what he can borrow or buy. (Stealing a person's ideas is plagiarism; stealing from many -- with footnotes -- is research.) For these reasons, authentication is second only to deduction in cost-effectiveness. The "literature search," "symposium" and "expert-consultant" are examples of authentication; "research analysis" is specifically designed to study and accelerate the process of information transfer.

The secondary problems of forecasting are of this nature. When our initial estimates fall wide, when we are led by our task into unfamiliar topics and disciplines, or when we define a subproblem for which we have no available methods, we are in a situation that calls for the process of authentication. Because no one man can hope to become expert in all the fields involved in modern forecasting, these same problems set the stage for cooperative and interdisciplinary studies. As Newton remarked on being honored for his discovery of the law of gravity, "If I have seen a little farther than the others, it was only because I have stood upon the shoulders of giants." While he may have been modest, the technique he implies is that of authentication. Since we also need to see a little farther than the others, one of the most useful procedures is to imitate Newton's technique.

However, one of the limiting factors in forecasting has been the inability on the part of many operators to shift reasoning from rational to empirical when the nature of their problem called for it. Whenever practical knowledge is no longer practical because it will neither explain the present nor predict the future, the utility of a rational approach becomes zero. There is no benefit in further application or acquisition of fallacious methods or invalid assumptions. The problem has become empirical.

(2) Empirical Problems are those which require new or more valid knowledge. Repeated failure of present axioms to predict or explain is a prime indication. Multiple competing or contradictory theories is another. Failure to discover applicable knowledge after extensive surveys is a third. Extreme dogmatism, certitude, or evidence of bias is suggestive of an empirical problem hidden behind a facade. Lack of evidence is a major symptom, as is the presence of ambiguous or overgeneralized assertions. The two main divisions within this class

of problems are those which raise questions concerning the quality of knowledge, and those which relate to the existence of knowledge. The former are problems of validity, the latter of induction.

(a) Problems of Validity are those in which knowledge is available, but of questionable quality. Evidence of a lack of predictive, evaluative or explanatory power is the primary indication; multiple but competing or contradictory theories in regard to the same phenomena is another, and suspected bias in either theory or data is a third. For the same reasons, any inductive postulate falls into this class of problems immediately. Validity of product is not determined by the inductive mode.

Other problems that fall into this class -- but are often overlooked -- are those involving authentication. When an expert or axiom has been located and identified as relevant to the initial problem or subproblem, this alone is often taken as evidence of validity. Problems of validity all concern the confidence with which existing knowledge may be used. This applies as well to experts and methods obtained through surveys as it does to inductive hypotheses or deductive premises. Confidence must be based on evidence, rather than faith in the source. Confidence in experts is based on an analogy between the past situation in which an individual performed well, and the present situation. The goodness of fit between the situations is critical if past performance is to be used as evidence.

Since validation, as any of the modes, may be applied at various levels of abstraction, whether one's problem of validity refers to premises or data will depend on whether it arose from deduction or induction. Deduction requires valid premises; induction requires valid data. The former may be recognized by failure of prediction; the latter is much more difficult to see, unless inductive postulates are automatically

submitted to an independent data base for validation. Even then, the problem of invalid data is only attacked by cross-reference. This is the reason for suggesting that input data -- and especially statistical data -- be coded with a confidence interval. Refinement of measurement and observation techniques are also indicated for this crucial problem area.

Another set of problems specific to this mode are those involving the degree of distortion introduced by observation. The Heisenberg uncertainty principle in the physical sciences holds that some distortion is unavoidable. The parallel distortion in social science is found in sample surveys, questionnaires, content analysis, and language translations. It may usually be seen as a feedback from observer to observed which biases the observation. "What does he want me to say?" "What is the answer that will put me in the best light?" and "What do the Soviets mean when they use the word... ?" are common examples. Over-simplification in controlled experiments is another; it precludes a representative sample, and the analogy between laboratory and real world conditions must be validated by outside observations. Remote observation and discreet sensors may act to minimize this class of problems in the social sciences. Use of the one-way glass window in clinical psychology is an early example of such an effort. Content analysis of documents as opposed to direct opinion survey is another. Refinement of sensors to reduce feedback distortions in the social sciences is a promising area of inquiry, but one that still requires further effort. It does not appear to be close to a Heisenberg limit at this time.

A common discrimination among problems of validity is between direct and indirect validation. This pivots around the level of abstraction of a given premise, and whether it is observable. It is not, however, a problem of validity as such, but of problem recognition. If a concept is not directly observable, through distance, abstraction, time or especially

through lying in the humanistic realm, the initial problem is one for deduction. The only observable consequents of human opinion or belief are in patterns of verbal or physical behavior. You cannot tell what a man is thinking until he acts on his thoughts. On the other hand, to tell what he is thinking on the basis of his behavior patterns is a problem for inductive inference. Only when you have postulated what he is thinking and wish to test the postulate against further evidence in behavior, does the problem become one of validation. This, of course, applies to postulates concerning groups of men and nations as well as to individuals.

(b) Inductive Problems are those in which problem recognition has provided criteria of relevance, but relevant knowledge cannot be located. Here, deduction, authentication and validation have nothing to work with or on. No practical optimization is possible, and only the hard work of basic induction remains. In general, inductive problems are only identified by exhaustion of the other modes.

There are two types of induction, implicit or subjective, and explicit or systematic. Implicit or "in head" induction is usually the more rapid, and its product may be equally useful if validated. The process, however, is not replicable in most instances, and so dies with its possessor. Genius is not often transferable. Explicit induction records every step and all data involved. The specific problems of systematic induction are similar to those of validation; the need of adequate data by relevance, quantity and quality, possible distortion in observation, conscious and subconscious bias. Because of its one unique characteristic, induction has the problem of depending on the availability of a particular sort of individual, one who is capable of living and operating in uncertainty, yet possesses a rigorous imagination. The terms rigor and imagination would appear to be contradictory, but the necessity of finding people with just this combination of traits is a basic problem of induction.

A secondary problem is how to train people for these traits. The Socratic method of teaching by questions rather than answers and making the student reach for new (to him) concepts would appear the most useful technique. While not directly related to forecasting, this problem underlies some of the present difficulties when induction is indicated and such individuals are not available, and even more so it signifies the raw potential for inventiveness in a given society for the next generation. (Ref 23) How to identify such individuals is a problem not presently solved as far as we know. Psychology or modern education may have some recent insights of which we are not aware.

Definition of dimensionality and problems of measurement are inherent to this class of problems, although they call for interrogation of the problem and analysis of implications. Induction rests on data; if the data is not sorted according to dimensions, synthesis is prolonged. In many cases, it may be prearranged, but in a manner which will bias the induction. Coding of all social data to nation-state is one example; it hides relationships within nations. It is very difficult to draw general statements (or validate premises) with data so coded as to exclude relevant areas. This is why several quantitative basic researchers have asked that data coding be as specific and as comprehensive as possible. It makes a richer base for induction and for validation. In the history of science, the axioms Kepler derived for planetary motion could not have been induced or validated if Tycho Brahe had not refined his octants and simply collected data by observation. (Ref 24)

d. Misapplication of Mode

The modes of reasoning not only operate in areas of specific problems, but in particular sequences and combinations. Deduction and induction are both rational; they are often used together. Validation supports all other modes whenever a question of reliability is raised. Induction provides the development of new premises for all other modes. It is to be noted that, in the larger sense, all premises must originate

with induction, and since induction is incapable of producing certainty, all of our organized knowledge is tentative. This would appear to support Pliney's comment that "The only certainty is that nothing is certain. (Ref 25)

Our overall purpose then, is not to produce the impossible -- certainty -- but to build knowledge while systematically reducing uncertainty to its limits.

As simple as these modes might seem, evidence of misapplication is widespread. One of the more common examples in forecasting is the continued construction of sophisticated mathematical or computerized models on the basis of assumptions which are at best highly questionable -- and in some cases empirically denied -- concerning human, social or political behavior. Such models may well be used for the validation of social theory, but the decision maker who "buys" their products at this stage does so at considerable risk. Once premises are validated, models such as these will no doubt become valuable aids. Their internal logic is usually consistent: if the premises were valid the conclusions would be, but the validity of premises is unknown.

A second misapplication is the use of a "study" as an alternative to making decisions. Teams are set up to initiate basic research in areas where a quick but well-designed survey would show usable information already available. Parochialism is one cause of such misapplication: unnecessary duplication is the result. In many of these cases the problem is rational; authentication is indicated.

A third example is the inappropriate use of authentication. In the history of philosophy, the search for "criteria of validity" has attempted to employ the rational approach of submission to authority beyond its justifiable limits. This approach is indicated only when axioms have previously met the requirements of empirical validation. A more current

example is the use of axioms from the natural sciences to authenticate human (social science) problems. Because such axioms have been validated in one field is no guarantee they will also be valid in another.

Empirical validation is seldom misapplied, but often ignored. The only misapplication of note is that one may waste time reaffirming concepts which have been extensively and constantly supported. The major axioms of mathematics and the natural sciences have been so supported, and may be employed wherever relevant without further testing. The rules of formal logic have also been supported as adequate for the identification of rational fallacies. In the same light, there is little benefit in the recurrent speculations of "proving the worth" of systematic forecasting, planning and decision making. Their worth and the penalties for their alternatives have also been historically demonstrated.

e. Summation

The summation of this section is that no one mode of reasoning is a panacea to be applied habitually. Specific combinations and sequences can provide more effective solutions to a wide variety of problems. While decision makers and forecasters must continue to do the best they can with what they have, application of logic modes according to specific utility may serve to optimize their position in the near future, and indicate directions for systematic improvement.

No inference need be drawn that these findings are considered to be revelations. They are merely an explicit presentation of what most decision makers, researchers and forecasters appear in fact to be doing. Nor is this something to be surprised at; such a flexible combination of logic modes is one definition of the Scientific Method; (Ref 26) it is also a definition of the Systems Approach. (Ref 27)

IV. THE PROBLEM OF RELEVANT FORECASTS

The problem of relevance is even more general than the problem of reliability. Where reliability is a function of logical consistency and the validity of premises, relevance is the relationship between two fundamentally different types or realms of knowledge. The division is between concepts dealing with matters of fact and matters of value.

(Ref 28) Many of the difficulties encountered in forecasting may be traced to a widespread misunderstanding of the differences between these two realms of knowledge. The effect of this misunderstanding is that it leads forecasters to select and apply assumptions and methods which are inappropriate or only partially appropriate to the nature of their problem. This results in low power of prediction for exclusion of significant elements, and progressive decay in predictive power over increased time ranges. Today, it would appear that problems of realm and relevance are among the most difficult of the barriers being faced by forecasters, planners and decision makers.

Problems of realm are not easy to handle. They derive from some of the oldest and hardest argued areas of organized knowledge, having formed the basis for dividing philosophy into separate branches. This study will only attempt to illustrate their nature, establish a theoretical model for compact depiction, and reference some of their results in recognizable problems. This may serve to alert forecasters, planners and decision makers to some of these deeper barriers and the consequences to which they may lead. In later sections a few tentative approaches toward reducing them will be outlined.

The overall problem of forecasting has been identified as belonging to the study of organized knowledge, or philosophy. The discussion of the previous chapter comes from the philosophical divisions of epistemology and logic. The former deals with the origin, nature and limits of

knowledge, the latter with reasoning and the problem of validity. In this section, it will be equally apparent that problems of realm are concerned with ontology (the nature of reality), axiology (the nature of value and worth) and the two major divisions of epistemology (realistic and idealistic).

The specific and technical terminology of metaphysics, which includes these divisions, will be avoided as much as possible in this study because it is not a treatise on philosophy as such. However, it should be noted in passing that the study did not leap into this area by intuition or whim, but was led to it through interrogation and analysis of the problem at hand, which is the theory and problems of forecasting. It so happens that metaphysics and its various divisions are the areas of inquiry most relevant to the task.

It should also be noted that the term metaphysics does not refer solely to religious or mystical absolutes, but rather to the broadest categories into which knowledge may be divided. As already mentioned, these broad and basic problems are no longer reserved to philosophers; their symptoms lie within every forecast and on every executive's desk. Further, most of us now have access to many times the information available to the mental giants of the past. In order to organize and utilize such a volume of details, we must be able to synthesize them into the "big picture." Metaphysics is nothing more than a determined and continuing effort to get the big picture.

1. Reality and Potential Reality (Figure 11)

In ages past, only philosophers argued about the nature of reality; today the same arguments are heard in symposia among thoroughly practical forecasters, especially those problems concerned with the reality of future time. There are endless definitions, ranging from predestination

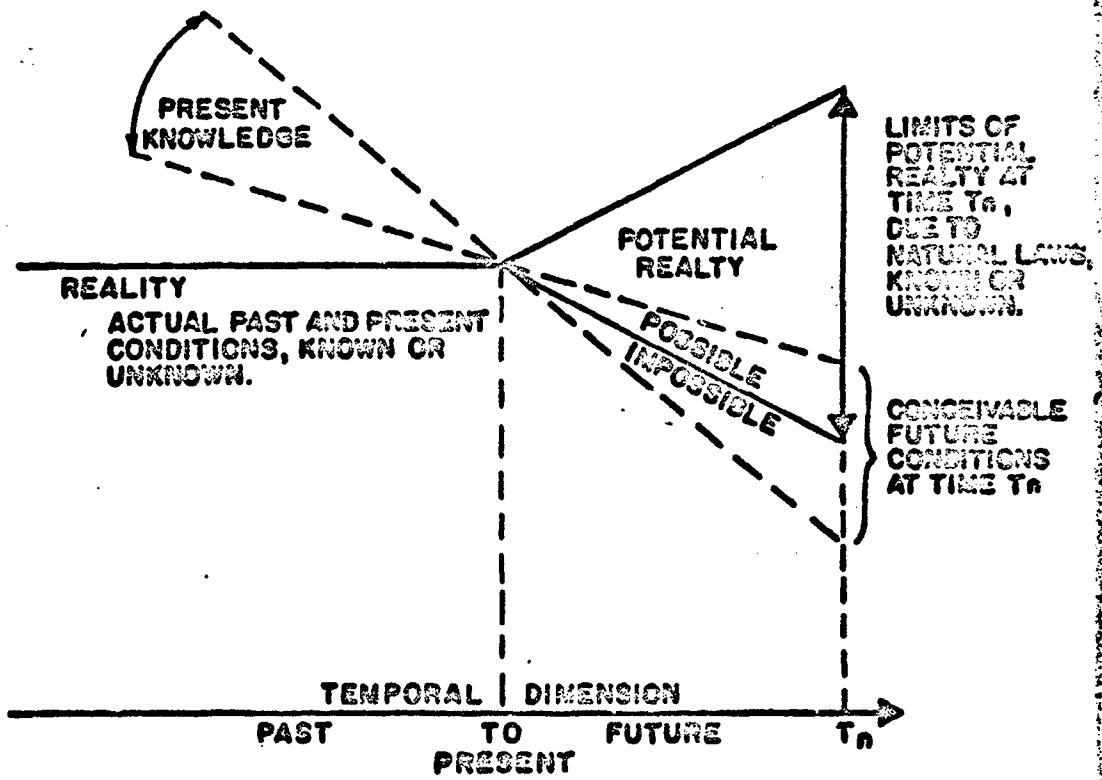


Figure 11. Reality, Potential Reality, and Knowledge

to complete volunteerism. For the purposes of this study, philosophical argument will be sidestepped in favor of Webster:

Reality: the quality or state of being real.

Real: (1) existing or happening as or in fact; actual, true, objectively so, etc.; not merely seeming, pretended, imagined, fictitious, nominal or ostensible. (6) in philosophy; existing objectively; actual (not merely possible or ideal).

This is a very interesting definition, the more so for the unusually large number of negatives it includes. It tells a great deal more of what reality is not than it does of what reality is. For instance, reality is not merely "the possible." However, unless the future is totally predetermined (which makes forecasting, planning and decision making rather useless, as seen in fatalism and determinism), it must be viewed as variations of possibility or potential. Therefore, reality does not include future time.

An additional distinction is drawn between "the real," and "the ideal, the seeming, pretended, imagined, etc." This implies that reality is neither what men imagine (or believe) it to be, nor what they might wish it to be. Reality is something apart from and independent of opinion.

With these observations, the above definition will be rearranged by a synthesis of implications into the following:

(1) Reality is the condition of actual existence; that which is or was true, regardless of human opinion, evaluation or belief.

(2) Potential Reality is that spectrum of possibilities whose combinations or permutations are capable of coming into reality through the passage of time. Its limits are those of natural laws, known or unknown.

From these definitions, it may be seen that the nature of reality is fixed; that which is or was true can no longer be changed. However, since reality is independent of human opinion, evaluation or belief, these

may be changed either toward or away from an accurate reflection of reality. In other words, human opinions may be changed through reinterpretation and reevaluation of the present and past, but the reality itself may not be changed. (Ref 30)

The second of these definitions implies that the nature of potential reality is parametric; that is, the future is flexible within limits. Within these limits -- known or unknown -- decision and the actions based on decision may alter that which comes from potential into real over time. However, decision and action also require an interval of time in which to operate; therefore, the near future will be less flexible than the more distant future. (Ref 31)

In addition, human actions are constrained by lack of knowledge. As knowledge increases over time and becomes more reliable, the range of known alternatives and thus of action will also increase. This will act to make the limits of expectable reality expand over time. The more closely present knowledge is aligned with present and past reality, the more closely expectable reality will align with potential reality, and the more reliable forecasts will become.

Finally, as will be recalled from earlier discussions, forecasting does not deal with reality as such, but with human opinion, evaluation and belief. All that is known of reality; past, present or potential, is still a matter of organized human knowledge. Therefore, reality is outside the forecasting frame of reference, but is still related to it. On the other hand, expectable reality is forecasting's frame of reference, and that portion of potential reality which it overlaps is the area in which knowledge or the lack of it can actually influence what does or does not come into reality. It is in this latter area that human actions may consciously direct the course of reality, and it is precisely this relationship between reality, potential reality and opinion from which the problems of relevance and realm arise.

2. The Realms of Knowledge: A Model

As indicated by these definitions, opinion and reality may be entirely independent of each other. However, opinion may be aligned with past or present reality, while potential reality may -- within limits -- be aligned with opinion. Such observations are suggestive of a vectoral model, with alignment shown as parallel vectors, and independence shown as orthogonal vectors. Between these axes will lie a vector space composed of various mixtures of the two. This is the reasoning behind the model illustrated in Figure 12. Discussion is as follows.

a. Realm of Realism

Realism, (1) a tendency to face facts and be practical rather than imaginary or visionary. (3) in philosophy, a) the doctrine that universals have objective reality; opposed to nominalism. b) the doctrine that material objects exist in themselves, apart from man's consciousness of them; opposed to idealism.

In this definition, "facts" would appear to indicate evidence independent of opinion, and the two doctrines in philosophy both imply reality as we have defined it. To "face facts" might be restated as to "align opinion with objective reality." Therefore, we will again simplify the definition:

Realism is that portion of organized knowledge dealing with facts; i.e., with entities, properties and relationships which may be shown to exist regardless of human opinion, evaluation, or belief.

All schools of "objectivism" or the "objective approach" belong to this realm. Their primary viewpoint is that of the dispassionate outside observer who describes, explains and projects, but does not evaluate subjectively. Field theory, of course, places the observer and observed into the same context; however, since it was developed in the natural sciences, it still maintains his dispassionate orientation.

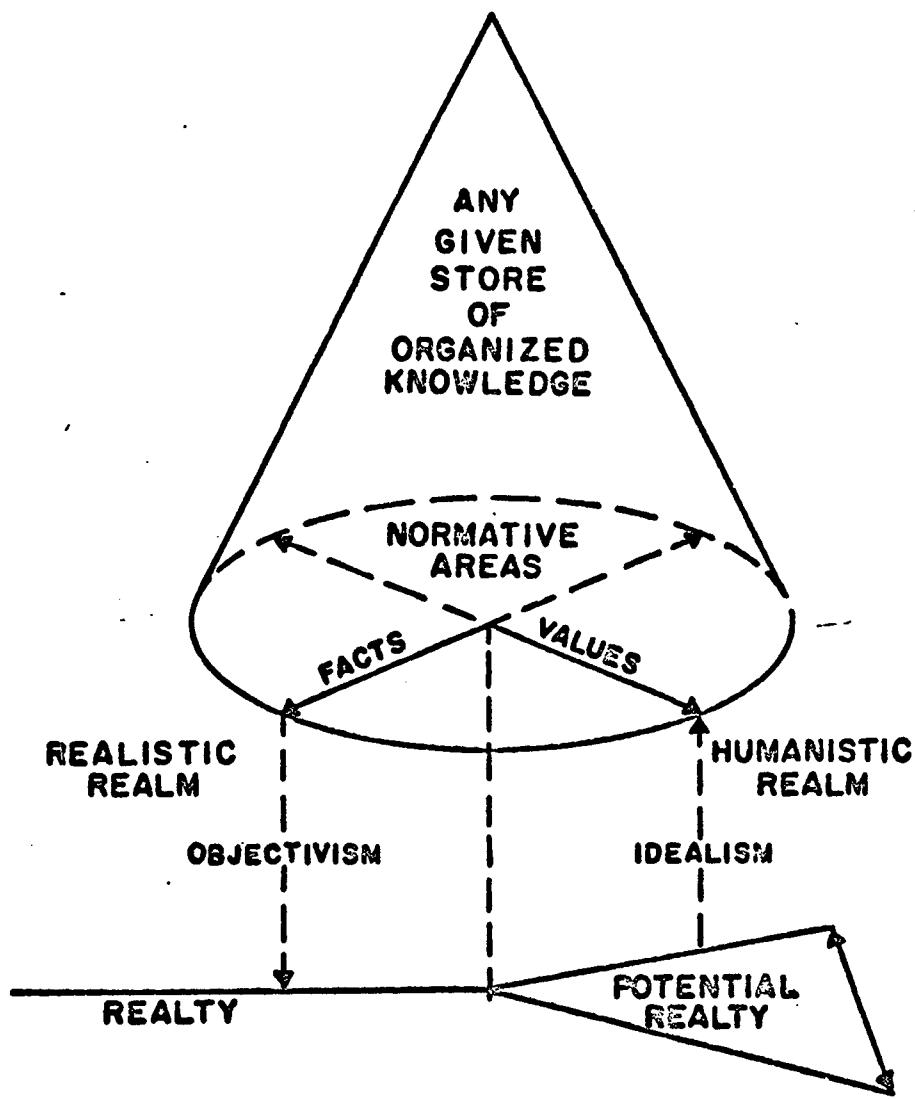


Figure 12. Realms of Knowledge

Objectivism has great value in this realm, which includes most of the physical and biological sciences. A planet, machine, missile, electronic field, chemical combination, microorganism or ecological system can be shown to operate according to certain principles, regardless of what men may think or wish. Opinions which misrepresent these principles (do not align with reality) may be submitted to the higher authority of empirical evidence and demonstrated as being in error. Differences of opinion between individuals and between competing hypotheses also have such higher authority available. It is largely because their subject matter has been restricted to reality as independent of opinion that disciplines representing this realm have been developed far beyond the others. Any subject which actually falls within this realm may become highly predictable once its fundamental principles are known. This is why an emphasis on strict objectivity has become a norm for sciences dealing with realistic problems; fancy, bias, wishful thinking and speculation are disutilities; only the factual evidence is authoritative. Thus, the goal of realism is to discover, describe, explain and project these natural properties and principles.

The point at which knowledge of natural principles is utilized is precisely where realism ceases. How such knowledge is to be used -- for what purposes and to what ends -- involves questions of human value and preference. And human values may be entirely independent of reality, designed to change rather than reflect it. This leads us to the second realm of knowledge.

b. Realm of Humanism

Humanism, (1) study of classical Greek and Latin literature or culture, (2) study or teaching of the humanities; literature, language, the fine arts, philosophy, etc., and (3) any system of thought or action concerned with the interests and ideals of people, as opposed to the natural world or religion.

Of these three definitions, the first is obviously inappropriate, and the second has been so limited by convention as to be inadequate. The third, however, is much closer to our need. For the purposes of this study, it will be expanded slightly and generalized as follows:

Humanism is that portion of organized knowledge dealing with values; i.e., with entities, properties and relationships which owe their existence entirely to human opinion, evaluation, or belief.

Many of the social sciences and humanities deal with subject matter that falls within this realm, and although most of them might object to being included in an "other than realistic" category, their subject matter is not realistic. Therefore, the indicated viewpoint for research in this realm is that of the involved, subjective observer who perceives reality imperfectly, but nevertheless attaches values to nearly all he perceives.

This viewpoint is an operational necessity for the study of values, because one of their primary characteristics is relativity; they depend on many subjective points of view. The worth of a coin, painting, mode of reasoning, or "way of life," the value of a person, political party, or nation, even victory and defeat can be shown to vary from individual to individual, culture to culture, place to place, and time to time. Throughout this realm, some people will love what others hate, seek what others shun, and defend what others attack.

In all of these, one pattern is evident; men and groups of men do perceive and evaluate in differing ways, and there is no higher authority for what they believe than the men themselves. We may assert what we think they believe, but this assertion is our own and not theirs; we may postulate what they value, but we must go to them for the evidence to support our postulate. (Ref 32)

These differing patterns of perception and evaluation set the dividing lines between in group and out group, we and they, friend and foe.

They establish and maintain the existence of such humanistic entities as families, factions, parties, nations, ideologies and religions. None of these continue to exist when people cease to value them and identify with them. To state the case more sharply; the nation-state is not a biological organism nor an expanse of geography. It is a humanistic entity, resting on the aggregation of human beings who identify themselves with it. Lacking this one factor, the nation dissolves and ceases to exist except in the history books.

It is also along the dividing lines between such humanistic entities or action groups that conflicts develop. Things do not conflict, they simply conform to natural laws. It is the interests, ideals, values and goals of human beings that conflict both with natural laws and with each other. We have found by trial and error that one cannot forecast world conditions as he would planetary motions and then deduce future conflicts. The causes of conflict lie in patterns of human opinion, evaluation and belief; one must project these patterns, infer impending conflicts from them, additionally infer the likely outcomes of such conflicts, and from these deduce the future condition. Forecasting of conflicts thus requires the humanistic approach, wherein one seeks for understanding of others' perspective. The researcher must be able to immerse himself in the specific point-of-view of the group he wishes to study. There is no higher authority for what a given group of people believe than the group itself, and what they believe may hold little correspondence to reality.

There are, of course, many hazards to the humanistic approach, and many difficulties, some of which will be discussed in following sections. One of the more notable hazards is that a researcher's immersion in another perspective will be neither tentative nor operational, but permanent. People who study the problems of ethnic groups and cultures have a tendency to so accommodate or identify themselves with the values

of the group that they become partisan advocates rather than researchers. This may be seen as an inversion of the Heisenberg principle, wherein the field to be observed acts to distort the sensor.

The operationally subjective approach may be illustrated by our expansion of the third definition of humanism. This was done primarily to include the question of religion. Without becoming involved in debate as to the essential reality of God -- however defined -- we must attempt to ascertain the various concepts of God held by different groups of people. This is because the differing conceptions of God, of the nature of man, of time, and of reality itself are humanistic images which act to condition subsequent patterns of perception, decision and action. While the images may be totally unrealistic, the patterns of action are themselves imminently real and do alter the future condition. It is just such patterns of decision and action that we wish to forecast; therefore, we must study what specific groups of people believe, and what they value.

The basic consideration of this discussion -- and the line of reasoning which led us to a metaphysical approach -- was the problem areas of forecasting. At present, forecasters are doing relatively well with everything except human behavior, and especially the behavior of large groups. However, these problems comprise a major portion of their subject, whether this is economic, political, technological, military, or sociological forecasting. It appears the largest single subset of our problems, and presently the most difficult to deal with, falls into the humanistic realm. (Ref 33)

In order for academic disciplines, research and forecasting projects whose subject matter includes factors influenced by human opinion, evaluation or belief to attain predictive power, application of the scientific method is indicated. However, the nature of the realm must also be taken into consideration; here, what people think does matter, whether

their opinions are realistic or not. It will do little good to rely on a purely realistic approach, because the subject matter is not purely realistic. A humanistic approach must be designed to find out what beliefs people hold and what they value; it must also attempt to ascertain the likely consequents in behavior which the holding of certain beliefs would imply. It is at this point -- in the patterns of human behavior -- where subjective images and values impact on reality.

c. Area of Normalism

There is no such word as "normalism;" it is derived from and designed to include all such concepts as norm, normal, normality and normative. All of these refer to standards, models, patterns, expected or preferred values, etc., and the process of conforming something with such standards. We define the term as:

Normalism is that portion of organized knowledge dealing with both values and facts; i.e., with what ought to be, and what actually is.

In terms of this model, normalism is represented by the vector space between realism and humanism, containing elements of both, and acting to alter one to the other. Two basic types of normalism may be defined as, (1) objectivism, whose goal is to align human opinion with dispassionate reality, and whose means is factual education from present or past evidence; and (2) idealism, whose goal is to align future reality with human values, and whose means is normative education, persuasion or prescription designed to alter the patterns of human behavior.

Such studies as public administration, corporate management, development and welfare economics, military training and standardization, ethics and religion all deal with normative problems. So do the practical technologies of public, corporate, military, professional and personal forecasting, planning, policy formulation and decision making.

All of these activities involve both problems of value and problems of fact.

On the one hand, opinions which are as dispassionate and objective as possible are required for a realistic appraisal of available means, techniques, methods, capabilities and resources. On the other, the ends, goals, quotas, ideals, aspirations and standards which these efforts attempt to meet are not designed to describe reality, but desirable future conditions. Even a "realistic" goal does not exist in dispassionate reality, but in human minds. It is considered realistic only because an appraisal of capabilities has indicated it is conceivably attainable. "Idealistic" goals are those which do not appear to be attainable.

In the area of goals, being objective is not essential and may well be a detriment. Human values are being sought, whether these pertain to an individual or a composite (corporate) entity. Such concepts as corporate product, national interest, public good, mission assignment and party platform are neither dispassionate nor objective; they are human values and individuals included in these groups are expected to pursue them as their own, or in preference to their own. Systems of rewards and punishments are designed to insure that such is indeed the case. In this context, there is no functional difference between a church doctrine, a national policy, a standard of professional ethics, a company policy, and a pilot's checklist; they all direct human behavior toward the attainment of some concept of positive value or the avoidance of its opposite. They all reflect something that someone wants, or wants done.

Disciplines and activities whose subject matter includes both human and natural factors are much in need of development toward prediction, but again, the nature of the problem must be taken into account. Ends, goals, aspirations, ideals and needs -- all of which may be clustered under the term demand -- are humanistic and require a humanistic approach. Means, capacities, capabilities and resources -- which may be subsumed under supply -- require a realistic appraisal. Exclusion of

either approach when a problem combines elements of both realms is the primary problem of realm. It leads to weak prediction for exclusion of significant factors, and to inaccurate planning, inadequately based decision, and potential failure of subsequent actions. Some specific examples of such causal chains will be discussed in the next section.

3. Problems of Realm

Problems of realm result from misunderstanding the essential nature of one's problem or its elements, in terms of the relative causal impact of human opinion, evaluation or belief. They lead to misapplication of effort and resources, based on assumptions which are not relevant to the problem. Consequently, power of prediction and explanation are poor. This indicates the first problem of realm is to recognize that such a problem exists, and the first technique is to interrogate one's original problem along lines of causality to determine which elements depend on human factors and which do not. Once this is done, the relevant approach may be applied to each subset.

a. Realistic Problems

There are three divisions within this class of problems; (1) those having to do with physical laws, known or unknown, (2) those dealing with biological factors, and (3) those which concern past or present human behavior.

(1) Physical Problems are easily recognized as independent of human opinion. It is not difficult to see that the humanistic approach of studying what various groups of people believe is irrelevant to such questions as whether the earth is round, whether heavy bodies fall faster than lighter ones, and whether light is composed of waves or particles. Chemical reactions do not depend on belief, nor do such phenomena as solar cycles, earthquakes, volcanoes, tides, floods and winds. Studies directed toward the principles of mechanics and the various

energy fields pose problems of this class. Mathematics is a realistic discipline in this sense; it is also independent of opinion. $2 \times 2 = 4$ whether you like it or not.

(2) Biological Problems derive from attempts to understand the structure, functions and parameters of living systems. From the virus to the bodily processes of mankind, they are realistic in nature. At that level, the border between physical and psychosomatic illness is also the line between realistic and humanistic problems. A man who lacks adequate food, water, oxygen and warmth will die no matter what he thinks. Ecological systems are not independent of human action, but they are independent of human opinion. They obey their own laws, which man may learn and apply, but may not violate without experiencing the necessary consequences. Food production is a biological problem; it depends on the characteristics of living systems. So is disease, with its sub-problems in sanitation, medicine and hygiene. Air and water pollution, and the accumulation of atomic waste, are largely within this division, due to the biological requirements of the human organism and those upon which it depends. The population explosion, on the other hand, is also a humanistic problem, dependent on attitudes toward birth control and ideal family size. Where not dealt with on this level, it reverts to a biological problem of survival.

(3) Past and Present Human Behavior is a realistic problem only because man is incapable of actually altering the past. Human actions are real once accomplished and thus present the same sort of evidence as physical or biological phenomena. It should be noted that the subject matter of behavioral psychology is action, not opinion. The present overlapping between biological and behavioral studies is not surprising; they deal with the same class of problems. Opinions which have not yet been acted upon do not present evidence in reality, and the

"behavioral school" confines itself to realistic evidence. So long as one only asks what people actually did or are doing, the realistic approach is indicated; once he asks why people did something or what they will do in future, the humanistic approach is more relevant.

(4) Capabilities is a term that subsumes many realistic problems. The implication is that capabilities are limiting or enabling parameters, natural resources or constraints. Economic resources, capital goods, industrial capacity, population, area, and such "natural endowments" are seen in this category. So is military posture -- number of men under arms, number of guns, ships, tanks, planes, missiles, warheads, etc. "National power" has long been studied through realistic appraisal of capabilities, and insofar as these are independent of national intentions, the approach would appear sound. Many nations are capability limited no matter what they might wish to do; others are so limited only in certain areas or directions. As an aggregation of physical, biological and past behavioral factors, study of capabilities relates to the supply side of many demand-supply situations. Search for information on capabilities follows from the question: "What could we (or they) do?"

In summary, the distinguishing feature of realistic problems is their independence of human opinion. The subjects of physical and biological science fall into this class by definition; past and present human behavior does so because what has been done can no longer be changed by wishing it otherwise. The future condition does not fall into this class of problems, however, for two reasons. First, although natural laws will continue to apply, they may be manipulated through man's knowledge of them; and second, the future human behavior which includes such manipulation depends for its patterns on humanistic values, ideals, perceptions and beliefs. Thus, only those conditions which man cannot be expected to do anything about within the forecast period may be projected on a purely realistic basis.

b. Humanistic Problems

In the realm of ideals, values, prescriptions and norms, what people think does matter, and through the medium of human action, these intangible factors do influence the future. Any question that includes the words "should," "worth," "cost," or "risk" is likely to fall into this class of problems. Such questions do not refer to reality, but to opinion. They do not ask what is, but what ought to be, or what value is to be placed on something. Here, the realistic approach is not relevant. People will act as though the earth were flat -- by refusing to venture out to the imagined precipice -- so long as they believe it is. They will stand and fight or turn and run, work or loaf, build or destroy, depending on what they think is so. Men will kill for an ideal and die for a dream. Any approach which discounts such factors or merely assumes all men will react identically in similar conditions can neither explain the past nor predict the future. Difference of opinion makes more than horse races; it also makes ethnic groups, political parties, nations, and the entire spectrum of conflict and cooperation.

(1) Problems of Evaluation belong to this class; the assignment of values is a peculiarly human function. We note that even in sophisticated computer programs for analysis of alternatives, the cost, risk and worth factors must be entered by human operators. The entire field of "cost-effectiveness" implies the relativistic questions of this realm, "Cost to whom, in what terms, compared to what other values, and effectiveness at doing what?" Problems of evaluation are now being faced by decision makers and forecasters in all areas; the application and allocation of science and technology, economic development and welfare, industrial management and market forecasting, military mission and force structure planning, international and domestic policy, and structuring of party platforms -- to name only a few.

In all of these, problems of evaluation are seen as the demand side of every demand supply situation. "What do we (they) want?" And demands rest squarely on the psychology of human values, either individual or group. This is why the social sciences which deal with clusters of human values are in accelerating demand; decision makers want improved information on problems of value, their own as well as others. What the leaders of the Soviet Union intend to do with them may be more important than the number of missiles they actually have. Such problems are no longer purely philosophical or academic. Values matter.

(2) Problems of Prescription are those which involve what should be done. Sequentially, they follow problems of value, since what should be done depends on what one wants done. The problems of management, command, and executive decision fall into this division when statutes, standards, procedures, ethics and policies must be defined. Optimization of behavior is a synonym. While nonhuman systems also show the characteristics of optimization, i.e., a standard reference with positive and negative feedback, the distinguishing property of humanistic optimization is that the central reference is a value-judgment. All such systems are designed to feed back rewards and punishments to increase the standard value-judgment if it is positive, and to minimize it if negative. These are seen as ideals or goals and steering signals for behavior. If one's problem is of this type, he must have information concerning both the ideal or goal, and the value patterns of those he would influence.

The area of influence is a special case; prescription of values. Here one attempts to control not only what others do, but what they value. Normative education, enculturation, indoctrination, socialization, advertising and propaganda fall into this subclass. This is the manner in which the sacred nature (religious or ideological) of persons, places, objects and concepts is endowed from generation to generation. So is bigotry.

prejudice, fatalism, ethnic hatreds and the seeds of future violence. The value of "ingenuity" or innovation is significant for forecasting the technology of any given society. The worth of time, of maintenance and repair, of blood kinship versus the public good, and the value of party loyalty all hold implications of attitude and subsequent behavior. The definitions of such terms as integrity, patriotism, aggression, freedom, responsibility, and progress in various cultures or nations are vital for forecasting. For instance, normative education may be accomplished by so framing definitions that the desired conclusions follow from them.

The Dictionary of the Russian Language states:

Aggression is the armed attack by one or several imperialist countries against other countries with a view to the occupation of their territories, their forcible subjugation, and the exploitation of their peoples; the foreign policy of which it is the principal instrument, for example; the Atlantic Pact of 1949. (Ref 34)

In forecasting relative rates of population increase, the humanistic variable; ideal family size underlies birth rates, population expansion, load on education, food requirements, domestic labor force, housing demand, economic and social unrest, and the number of men available for military service. Factual knowledge of birth control techniques and the necessary devices may be supplied, but if the masses of people prefer to have large families, the capability to limit them is useless. Thus, the steering point for population control is through propaganda, advertising and demonstrations designed to persuade the people of what they ought to value. Such tactics alter demand.

(3) Intentions is a term that encompasses many humanistic problems. It refers to both ends and preferred means, i.e., to ideals and ethics. It excludes considerations of capability, in that it implies what a man or group would do if they could. National policy is as much a matter of intentions as it is of capabilities. In the current

international environment, some nations -- notably the United States, but including some others -- appear to be intent limited. They choose to refrain from doing what they are capable of doing. In fact, the entire concept of limited war is based on the intention of self-restraint and utilization of less than full capabilities. It follows from a particular set of ideals and ethics. On the other hand, invasion and insurgency are symptoms of another sort of intention, based on a different set of ideals and ethics. It would be very difficult to forecast U.S. actions on the basis of capability alone. It would also be difficult to forecast China's actions on that basis, since the past behavior of the government implies that idealistic considerations have at times superseded realistic appraisals. Thus, forecasting the onset of hostilities, analysis of potential threat, identification of military missions from strategic to civil action, allocation of resources, and programming of supporting research all depend on what various groups of people believe. This is the causal line of demand and of relevance; physical science and technology may then furnish the indicated supply line, to the limits of capability. The same lines also apply in economic, political and social problems.

c. Normative Problems

The nature of normative problems is to combine in one context both natural and human forcing functions or causal factors. The great majority of current forecasting, planning, and decision making activities appear to contain various mixtures of the two under one or another of their many synonyms: demand and supply, intentions and capabilities, ends and means, attitudes and abilities, policy and power. In all of these, both realms must be taken into account. (Ref 35)

In a normative problem, exclusion of the humanistic or demand factors makes it impossible to ascertain the relevance of any given capability or proposed capability. What happens is that past or present

demand (national policy, mission concepts, market preference, etc.), is assumed as constant and capabilities are designed to meet it. When people change their minds, demand changes, and capabilities become irrelevant. The result is capability which is available but no longer needed, and capability which is now needed but not available. Being prepared to refight the last war or solve the last depression are cases in point.

On the other hand, failure to consider the realistic or supply factors makes it impossible to determine the practicality of any given ideal, goal, plan or intention. When decision and action are based on idealistic considerations alone, it leads to catastrophic failure for lack of capability, and loss of opportunities through failure to apply existing capability. The "charge of the light brigade," the "great leap forward" in China, and the Japanese initiation of World War II, are examples.

Thus, in order to forecast, plan, or decide when faced with a problem that includes both human and natural causes, one must differentiate it into subproblems in order to apply the relevant approaches. If he does not, the alternatives are likely to be irrelevant and thus useless capability, or impractical and thus useless ambitions and desires.

Differentiation of problems by the causal nature of their elements follows from the question, "Which parts of this problem rest on somebody's opinion, and which do not?" The second question for humanistic elements is, "Upon whose opinion does it rest?" Although this is a specific operation best accomplished for individual problems, a few examples of typical clusters may be given.

(1) Any Application of Science of Technology is a normative problem. As long as studies are pursued solely in order to explain natural properties and processes, the problems are more nearly realistic -- although even the desire to pursue knowledge for its own sake is

a value-judgment. However, once one considers the application of knowledge to further some particular purpose or achieve a goal, human values enter in force, and the problem becomes definitely normative. The purpose or goal takes on the character of demand, while knowledge of natural laws becomes a means of supplying that demand. Again, demand sets the direction of effort, and supply determines the likelihood of success in the terms given.

One of the characteristics of natural laws is their ambidexterity; knowledge of their principles may serve a variety of human values. When a group of people understands how to manipulate nuclear reactions, they can apply that knowledge to light or to destroy cities. Biochemistry can furnish fertilizer or nerve gas; a people who have developed helicopters can use them to evacuate flood victims or to fire rockets. Even a hammer may be used to build houses or to smash skulls. In every case involving the application of science or technology, what is actually done with a given capability -- and which capabilities are pushed for development -- will depend on human values. Conversely, the degree to which a given value is satisfied will depend on capabilities.

(2) Technological Forecasting is essentially a normative problem for exactly the same reasons. However, much of the recent emphasis has been on extrapolation of supply trends -- production and capabilities.

There have been many books and articles written concerning the impact of technology on society, but relatively few on the theme that human values direct the course of future technology. (Ref 36) Both appear to be valid. What is the future of medicine in a society that does not value human life or considers disease the just punishment of a man's sins? How can birth control techniques be disseminated to a people whose older members starve if they do not have numerous children to

support them? Does an advanced space program depend more heavily on technical possibilities or on budgetary levels conditioned by society's willingness to spend tax money on space exploration?

Even when watered down to the level of desire or fancy, necessity is still the mother of invention, and unneeded inventions are often left behind like motherless orphans until a need for them becomes apparent. Like the electric automobile.

This does not imply that forecasting technical capabilities and the potential supply of future technology is useless; on the contrary, the real limits must be known. However, it does suggest that decision makers may expect only parameters and possibilities from this approach, and should place less confidence in projections of future reality that ignore the direction-finding side of demand.

We observe some patterns in the evolution of technology which may assist in refining supply extrapolations. In those situations where development of technology is slow or stagnant, supply and demand are roughly equal. This does not mean that people are happy with conditions, but that they cannot afford to change without assurance that new techniques will improve their lot. Also, if advanced techniques are supplied by innovation or transfer, they are likely to be rejected for lack of recognized need or demand. This is why ridicule is often directed at early innovators, and apathy is found in many attempts to transfer technology to underdeveloped areas; people do not see the need or value of the new ideas. Thus, before technological change can be forecast, the attitudes of the recipient population must be studied. Dissemination and utilization of new techniques or tools follows widespread recognition of need. Supply cannot by itself create demand: people must see its value for themselves, or be led to see it through advertising, propaganda, or demonstration.

On the other hand, once demand for technology does begin to increase, it often does so far more rapidly than supply. This is because demand is a matter of personal opinion and evaluation -- it may change instantaneously in the mind of any given person, or sweep through a society according to its rate of communications and openness to new ideas. Supply, however, is a matter of production, capabilities and resources. These change more slowly. Even when the desired commodity is technical knowledge such factors as the training of teachers, construction of schools and the time required to transfer technical knowledge by education or demonstration all add delays to the supply response.

As technology evolves and supply continues to increase, the demand-supply situation may again approach equilibrium. The symptoms are now those of elastic demand: people can pick and choose between several means of doing the same thing, several types of equipment, systems, etc. Thus, as supply of technology increases, the problem becomes proportionately more humanistic. This is why many technological forecasts now show the characteristics of advertising: demand for the product is elastic. Such forecasts present decision makers and potential customers with a range of future goods and services among which to choose. The future reality (and the future well-being of the producer) depends heavily on the choices and thus on the value-structure of the consumer. From consumer reaction to such forecasts, producers may plan or replan their supply policies. This is one form of social science or humanistic research -- its goal is to ascertain the values of certain groups of people.

(3) Military Mission Identification and Analysis, force structure and policy planning, resource allocation, and direction for basic and applied research programs all belong in the normative area. When a commander speaks of the "mission" of his unit, he refers to the demand it must attempt to meet. The pilot taking off on a "mission" is supplying a specific series of actions to accomplish a specific series of demands.

The humanistic-realistic combination may also be seen in the two terms, Mission Identification and Mission Analysis. The former deals with potential demand for future missions, "What will we be required to do?" "How will these demands differ from those for which we are now prepared?" Mission Identification rests on the intentions of the United States and those of various groups of people around the world, some of which form national governments and some of which do not. Mission Analysis, on the other hand, requires that demand be given or assumed (present national policy, tactical doctrine, commander's estimate, scenario, etc.). It then concentrates forecast and analysis on supply--capabilities, resources, forces in being or proposed, etc. --for the United States and various other groups. The operational question is, "What can we (they) do? (Given these intentions)."

(4) Any Allocation of Resources is also normative. One cannot realistically allocate what he does not have and cannot obtain. Neither can he decide how to allocate what he does have unless he is aware of where and how it is needed or desired. Even the existence of natural resources contains a humanistic element; the iron ore in the Mesabi Range was not a resource to the American Indians because they had no recognized need or demand for it. Neither was the oil deposited under the continent, nor the veins of coal.

This normative combination is illustrated by a recent study conducted by the Office of Water Resources Research, United States Department of the Interior, and published in their annual report to the President. In the section entitled, Areas for Intensified Research, it states:

The Panel finds, as did the Panel convened in 1965, a significant gap in research in the social and behavioral sciences.... The ways in which people and institutions perceive water and water problems--in the values assigned to water, the uses they wish to make of water, their recognition and attitudes toward solutions of water problems--will be

the ultimate factors determining the wisdom with which water resources are conserved and developed. Knowledge of the properties of water, of techniques for planning, of cleansing, of efficient utilization, of costs and benefits is essential. But the degree to which knowledge actually is used is a function of attitudes. (Ref 37)

Thus, drouth may be defined as a situation in which demand for water exceeds supply, and flood a situation in which supply exceeds demand. A dam which increases supply to meet demand in one area may well reduce it below demand in another. From this point, the problem often moves into the political arena with actions in legislatures, executive branches and courts.

(5) Deterrence as a Policy, Foreign or Domestic Aid, Threat Analysis and Conflict Forecasting each combine two normative pairs; the intentions and the capabilities of both actors or countries under consideration.

The policy of deterrence is itself the intention to preserve peace by neither initiating war nor allowing another to do so. "Containment" is a synonym. However, without the actual capability to wage war, deterrence is an idealistic dream. Further, the capability to wage war does not conform to this policy unless it is also intent-limited or self-restrained. Thus, the country which would apply deterrence as a policy must be able to initiate war, but choose not to do so.

On the part of the country to be deterred, these conditions must be reversed. It must intend to initiate war, because if it is already self-restrained, deterrence is meaningless. This is why Canada's capability does not pose a threat to the United States. On the other hand, if a country does intend to initiate armed conflict or to advance its interests by destructive means, it may only be deterred if it also believes it is not able to do so, or that its own risk is greater than its potential gain. This depends on its own perception of the other's resolve (intentions) and

power to inflict unacceptable damage (capabilities). The acceptability of damage depends on the value structure of the deterred nation. Only under this combination may deterrence be expected to hold.

If a nation intends to initiate war, and does not believe in its own vulnerability, in the capability and resolve of the deterring power, or that it stands to lose more than it stands to gain, that nation cannot be prevented from making the attempt.

While the realities of relative capability will determine the outcome of war, humanistic attitudes and values determine the onset -- or its avoidance. This is why Communist China does pose a threat to the United States, regardless of relative capabilities: the present government of China gives evidence it has based decision and action on ideals and ideology without adequate consideration of realities. The catastrophic failure of the "great leap forward," and the "cultural revolution" show this characteristic; so does the "red before expert" policy of education and promotion. The reality of deterrence -- and thus of conflict -- rests finally on the psychology of the nation to be deterred.

A parallel problem is found in foreign aid and urban renewal; on one side, assistance requires both the desire and the ability to help; on the other, it requires both the recognition and the reality of need. The ability to aid does not lead to action unless accompanied by the desire; the desire is useless without the ability. Assistance is unreal if only directed toward what people think they need and not toward what they actually need; this is the area of waste in aid programs. Conversely, even massive assistance directed to real needs is likely to be rejected and resented if that need is not recognized by the recipient. (Ref 38) Unasked-for aid is often self-defeating because the recipient views it as a covert threat or bribe. Thus, in order to help someone, you must know what he needs and also what he values; like threat, promise depends

heavily on the psychology of the recipient. So then, do both damage and aid, with their resultant conditions.

In sum, the requirement of all normative problems is to study both reality and humanity; the proper study of reality is dispassionate fact; the proper study of mankind is man.

V. THE TEMPORAL DIMENSION

The arbitrary concept of time, whether measured by calendars or clocks, is not the true context of forecasting, but only one of the forecaster's tools. The true context is human knowledge, and especially knowledge in regard to the phenomenon called change. Clocks and calendars merely standardize our knowledge of one sort of change; the motions of earth in relation to sun and stars. These measures were borrowed from our knowledge of celestial mechanics, and they are most useful. However, they represent only small windows in the infinitely divisible continuum of relative motions. Because these standards are available does not necessarily make them relevant to all forecasting problems. Sequences, lags, reaction times, gestation periods, fertility spans, the life expectancies of men and machines, learning rates, communication delays and psychological time may also provide pertinent measures of change.

Although any of these may be referenced to celestial motions, selection of unit is not a minor matter. If the temporal units employed are too long, they will mask out significant variations in the phenomena being studied; if they are too short, major underlying trends and accelerations will go unnoticed. Thus, it is the actual rate of change in the phenomena itself which determines the relevance of temporal units, and not the converse. The tool must be fitted to the task.

Examples may be found in the planning cycles of several common operations. Military units in the field replan daily; in combat, they may

replan minute-by-minute. Consideration of periods longer than one year is relatively meaningless due to outside influences, and holds very little utility. However, the hardware development programs tend to operate on one to five year plans. This is necessitated by the sequences and lags inherent to such activities. Daily replanning is often a waste, an unnecessary burden. Planning for ranges longer than five years also becomes progressively inappropriate due to external influences. Finally, the basic research laboratories are forced to consider much longer ranges because of the extensive delays involved in the induction and validation of new knowledge, construction of experiments and test facilities, etc. Fifteen to twenty year planning is not uncommon because it often will take that long for a basic research decision to impact on subsequent reality.

As forecasting is implicit in all planning, the required range and thus the required temporal units for any forecasting project will be determined by the operation or activity it is designed to serve. Overly short forecast ranges are not only wasteful of effort, they also lead to the "backfire" effect, where a short run gain turns out to have been a long run loss. Overly long ranges are not common, but might be expected to produce little of the specific guidance needed for short range operations.

1. Reference Systems: Static and Dynamic

Since all forecasting involves relative motion or change, one of its primary requisites is a set of relevant and rigorously defined reference systems. This is because all motion is relative, and may only be defined by its relation to some point, line, plane or field. Change implies movement along a dimension, or within a reference system which incorporates several dimensions. Such a dimension must be assumed static (latitude, longitude, length, distance), of known rate (earth's rotation and revolution, the speed of light), or of known acceleration (earth's gravity).

Lack of predictive power may in many cases be traced to underdefined, inappropriate or purely intuitive reference systems.

Until Copernicus, astronomy took the earth as its reference; the result was poor prediction in those areas (planetary motions) where it was least appropriate. The cure for this weakness was not found in further deduction or projection on the basis of existing references and assumptions, but laborious empirical observation, synthesis, postulation and validation. The end products of this empirical inquiry were: (1) a new reference system, (2) a new understanding of dynamics, and (3) increased power of prediction.

a. Static Reference Systems are the first requirement, because all concepts of dynamics are built up through repeated observations from the same reference or perspective. An analogy may be drawn between forecasting and navigation, which present very similar problems. In either case, you will never know where you are going to be if you never know where you are or have been. To know where you are or have been requires you to fix a position at a specific moment in some standardized rate, and in relation to some sort of outside reference. In forecasting as in navigation, a primary avenue for improving knowledge of future positions is to improve knowledge of present positions. To do this, standardized concepts of length, direction and distance are greatly needed. In some areas of forecasting, we do not know which way is "up."

Trend extrapolation is a common example. We have little trouble with the abscissa; that represents celestial time. The problem arises with the question, "What are we really putting on the ordinate?" The ordinate of any extrapolation is also a dimension, the dimension of change over time. We cannot expect to obtain "well-behaved" curves if the data plotted along the assumed dimension represented by the ordinate is not dimensional, but an arbitrary, intuitive agglomeration. Reduction of this

problem calls for hard analysis and verification of dimensions before attempting to extrapolate.

b. Dynamic Reference Systems add a rate or acceleration to a standardized measure of length or distance. The rate of light presupposes the unit-length of one mile. The acceleration of gravity combines a unit of length (the foot) with a squared interval of a standardized rate (the second). This is how we build one concept on top of another. We must do the same sort of thing in other areas, where these physical units and rates are less appropriate. Such basic research may appear to have little relevance to practical and immediate forecasting or decision making, but it can build the conceptual tools these efforts are now lacking.

Of course, planning and decision making cannot simply stop and wait for the forecasters' millennium, when all the measures are systematized. The point is that we must do both; use what we now have, and at the same time attempt to improve it. One way to do this might be to investigate the reasoning patterns of successful decision makers. They appear to be intuitively employing both static and dynamic measures. (The crisis in Xlavania is getting hotter.) (Country X and country Y are on a collision course.) As the "scientific method" is no more than the explicit systematization of the reasoning patterns of men like Galileo, Kepler and Newton, so other areas may be improved by the same means.

2. Problems of Dynamics

Many of the problems in forecasting derive from various characteristics of dynamics. Bringing a few of these typical difficulties into this study may assist in their reduction. We cannot solve them here, but perhaps others can and will.

a. Vectoral Problems not only require definition of dimensions, but of orientation and length. Some forecasting areas appear to imply

vectorial models, but current concepts exclude one or the other of the two characteristics of a vector. For instance, Balance of Power theory in the study of international relations appears to assume a given orientation between national actors (180 degrees, or mutually opposed), and to concentrate on "power" or length. "Economic man" would appear to be defined as oriented at 90 degrees to other "economic men" as he is seen to maximize his own utility without attempting to either maximize or minimize anyone else's. In Theory of Games, when two actors attempt to maximize their own gain at the expense of the other, their two utilities are inverse functions (180 degree orientation) and the game is defined as "zero sum." Other games, such as cooperative (each attempting to maximize the others gain) or pyrrhic (where each attempts to reduce the others' gain, even at greater loss to himself), might also be defined in terms of vectoral orientations. Essentially, it would seem that all attitudinal situations (intent) might be described in terms of vectoral orientation, while power or force (capability) applies to length of vector. Further study of vectoral implications may hold promise of increasing the usefulness of theories in forecasting.

b. Dynamics and Abstraction. As mentioned in the discussion of conical organization, any entity, actor or organization will break down into a collectivity at a lower level of abstraction. This continuum of abstraction may provide a reference for several problems of forecasting. Such Systems Theory terms as input, output, throughput, feedback, and exchange imply both an initial frame of reference on, and motion in relation to, the Continuum of Abstraction. The motion of elements at like order of abstraction is often inexplicable in other terms; a more general concept is itself taken as frame of reference.

In terms of conical organization, one would expect the more general to move more slowly than its composing elements. While this assertion

needs much more validation, some observations would seem to support it. Societies change more slowly than individuals. "Universities remain the same, only the faces change." Nations exist beyond the lifetimes of their constituents. Living organisms change more slowly than the flow of elements and compounds of which they are composed. Water molecules move, but the river remains. In all of these, existence of the composite entity depends on the ratio between input and output of less general elements. Growth in biology, as in logic, is a process of integration: decay is a process of disintegration. It would appear that the relative motion of the parts to the whole (vertical axis) and to each other (horizontal axis) will define both the present state and future condition of any entity -- physical, biological, social, political, psychological or philosophical. Application of General Systems Theory to these areas may significantly improve forecasting.

c. Dynamics and Validity. Because it involves both static and dynamic premises, forecasting presents one unique class of problems. These concern the validity of dynamic premises (trends and analogies of change). The static premises which concern present or past conditions may be submitted to empirical evidence for validation, but the point at which deductions from dynamic premises (projections) may be tested against impartial evidence lies in the future, and the future presents no evidence.

The traditional approach to validation of dynamic premises is rational: specific consequences are deduced for a given point in time, and then one simply waits for the passage of time to make evidence available. This is largely how theory has been validated in the physical sciences. However, in forecasting and especially in long range forecasting we cannot afford to wait and see if our projections are valid. We are forced to act on the basis of projected conclusions before the evidence is

available to validate the premises from which we reached those conclusions. The condition a forecast might allow planners to obtain or avoid often arrives concurrently with the evidence necessary to verify the forecast.

This is a major problem, discussed by a number of writers. Some of their suggestions have been: (a) frequent iteration of forecasts and replanning, to allow rapid inclusion of new evidence as it becomes available, (b) "retrodiction," or projection backwards over time, (c) "postdiction," wherein one moves his point of view into the more distant past and applies his premise to forecast the recent past or present, and (d) simulation, to artificially accelerate the passage of time and make simulated evidence available more quickly.

All of these suggestions appear to be valuable, and are to be recommended. They follow from the statement that the future presents no evidence, the fact that validation absolutely requires evidence, and the identical nature (by logic mode) of prediction and explanation. As

Dr. Rudner puts it:

The logical structure of a scientific explanation is identical with that of a scientific prediction; the only difference between them being the temporal vantage point of the inquirer...we have an explanation for an event if, and only if, we could have predicted it (from an earlier point in time). (Ref 39)

We are primarily interested in the predictive function; thus, we may inverse the two terms (since they are given as identities), and state, "We only have the power to predict what we can also explain." This shows the utility of testing dynamic principles against present or past evidence, as the nature of the future shows the impossibility of testing them there.

It further implies why we can do no more than project known or assumed patterns of change; the absolutely unique event is not predictable

because it presents no evidence until it actually occurs. However, it would appear that most events we assume to be unique are later seen to have been repetitions of past patterns under a new name, or to have been produced by combinations of recognized patterns which could have provided precursors if their relationship had been known. Again, this stresses the point that the essential nature of a phenomenon is more important than the multiplicity of names it may assume.

d. The Two Basic Assumptions in regard to change over time. There has been a great deal of discussion concerning techniques of forecasting. Erich Jantsch lists well over 100 alternatives or variants. (Ref 40) Daniel Bell considers 12 modes of prediction in the social sciences, (Ref 41) and Bertrand de Jouvenel refers to five or six basic approaches. (Ref 42) Dmitry Ivanoff discusses 43 techniques applicable to forecasting, (Ref 43) and the Interservice Ad Hoc Committee's Report on Technological Forecasting Methodology shows 5 main divisions and 12 secondary divisions. (Ref 44)

Correlation of all available techniques by function and the assumptions they make in regard to change over time indicates only the two fundamental distinctions -- prognostication by analogy and trend extrapolation -- with the remaining differences referring to display techniques, explicit versus implicit statement, degree of sophistication, mathematization, computerization, etc. Some differentiations are made on the basis of subject area. Many of these distinctions appear to be identifiable on the basis of particular logic modes. All pattern recognition techniques (cluster analysis, multiple regression, factor analysis) are synthesizers, and belong to one stage of inductive reasoning. Many of the intuitive methods (DELPHI, TORQUE) follow the logic of authentication, in that they transfer knowledge from experts whose opinions are taken as authoritative. When only the projection stage is considered, all such

techniques assume that patterns of change will either continue into the future, or repeat under similar conditions.

There are three limitations inherent in trend forecasting; these derive from the assumption of continuance. First, all changes do not form a trend, and all trends do not continue. Second, the assumption of continuance precludes discovery of discontinuities and inflection points prior to the time they show up in the data base. And third, the assumption of continuance makes the reliability of any extrapolation decay in proportion to the range of the forecast. Over time, trends show increasing potential for alteration and decreasing potential for continuance. Thus, trend extrapolation is more applicable to short than to long ranges.

The one inherent limitation of forecasting by analogy is that no single analogy is capable of predicting beyond its own time range, even though it may do so every time its preconditions are met. In the case of long range forecasting, this often means that conditions themselves must be projected before application of analogies is fruitful. Hence, increasing forecast range requires an increase of scope, or the number of conditions to be considered for projection.

General systems theory reduces this problem by linking a series of analogies together in defining the "system." When the input preconditions for the first analogy are met, its output forms the preconditions for the next analogy, and so on through the entire model. This is why systems theory is capable of handling more complex problems and longer forecast ranges than simple prognostication alone.

Trend correlation is a combination of these two techniques, wherein a complex subject area is analyzed to its elements of change. These elements are extrapolated individually, and then reassembled by analogy to their past interrelationships. Essentially, the trends provide preconditions for the analogies, and the analogies show the result of composite

trends. This technique can show inflection or discontinuity of the composite. It appears to be the optimum approach to long range forecasting because it tends to reduce the inherent difficulties of both individual techniques.

3. Cause and Effect

Cause and effect is also a matter of dynamics. It should be stressed that the inclusion or exclusion of causal considerations has little effect on the reliability of forecasts. (Ref 45) One may project trends, sequences or analogies without ever considering cause and effect. Exclusion of cause and effect linkages does, however, act to reduce the relevance of forecasts, because when a planner or decision maker accepts a forecast he will then attempt to avoid or obtain its projected conclusions. To do this effectively, he must know the consequences of his various alternative actions. These consequences are the effects his actions may cause. If causation has been excluded from the forecast, he must either go elsewhere for this vital information, or run the risk of learning the consequences of his actions through trial and error (surprise).

As Newton remarked, "If you do not know the cause, you cannot produce the effect." Neither can you prevent the effect. Perhaps Newton should have added, "at will," because it is the human ability to consciously direct change to which this problem refers.

There are several models or types of causation, the simplest being direct causation (monocausal). Here, a single cause is both necessary and sufficient to produce a given effect. In other cases, there may be several causes necessary to produce the given effect, none of which are sufficient by themselves (multicausal). This was the condition we found in relation to effective forecasting. Often one will find key or underlying causes which produce many effects either singly or in combination with contributing causes (ignorance and certitude). Finally, there is the

phenomenon in the humanistic realm of internal causation, where the effect is not a consequent of the situation but of the internal perception and evaluation of different actors. All of these types need to be considered as they are found to be appropriate to various subjects, for further improvement of the degree to which forecasting may assist the planner and decision maker.

4. Summary

While celestial time is only one of the forecaster's tools, the temporal dimension of relative motion or change to which it refers is basic to all forecasting. Knowledge of relative motion or change is the forecaster's stock-in-trade. Thus, the various ways of looking at dynamic phenomena, with their methodological requirements and assumptions, are as important to the forecaster as are any set of craftsman's tools. A thorough awareness of the alternatives available and their characteristic strengths and weaknesses is essential for optimum effectiveness. Increased attention, research and validation of dynamic theories are avenues for continuing improvement.

VI. THE MATTER OF BIASED FORECASTS

Biased forecasts present a class of problems that involves the reliability of methods, the validity of conclusions, and the confidence one may place in such conclusions. Because of the extensive evidence of such bias in the large and increasing volume of forecasts now available, this matter is being given separate treatment, although it is essentially a problem of realm.

Biased forecasts are identified as a problem of realm because of the distinction between circumstantial or statistical bias -- which was discussed as a characteristic of empirical logics -- and normative or intentional bias. Most biased forecasts appear to belong to the latter category.

1. Normative Bias

Normative bias is a matter of values, ideals and ethics. It is purposeful, in that methods of preparation, projection or presentation are so constructed as to weight conclusions toward or away from specific value-judgments. It is one type of prescription or persuasion, designed to alter what people believe. It may be conscious or unconscious, designed to further personal or shared values, and accomplished either a priori or a posteriori.

A priori bias is one synonym of prejudice, and is often unconscious. Here, a conclusion is reached before evidence is gathered to support it. (Ref 46) Both preparation and presentation are usually weighted by the same implicit values. A posteriori bias is the attachment of value-judgments only after the gathering and weighing of evidence. In this case, the method of preparation is usually objective, with the bias applied consciously to the method of presentation.

a. Conscious Bias is the normative sub-realm of advertising, editorializing, lobbying, diplomacy, propaganda, salesmanship and all such "special pleading." Its major characteristic is that such individuals know their presentations are slanted, since they have done so deliberately in the hope of influencing someone's behavior. Scientifically oriented people generally tend to hold conscious bias in very low esteem, due to its incompatibility with the realistic approach. This may be why pure scientists often make poor salesmen: their own bias in this case has high positive utility in their own realm, but does not apply universally. In the humanistic realm, conscious bias has its own utility in moving human beings to action. Whether this utility is positive or negative depends on other considerations; primarily on the nature of changes in reality that result from someone's accepting and acting on a given exhortation, and the viewpoint of the person who evaluates those changes.

Some symptoms of possible conscious bias are: (1) the use of unbalanced evidence, (2) exaggerated claims for proposed methods, policies or projections, (3) absolute or certitudinous support of the concepts presented, in contrast to a similar emphasis on denial of competing concepts, (4) strong implications of great advantage to be gained by acceptance and/or great loss to be incurred by rejection of these proposals, and (5) usually unstressed implications of similar gain or loss to be incurred by the presenter or his identity group. These are, of course, all symptoms of the "hard sell," and biased forecasts are a form of salesmanship. There are several forecasting and research projects now ongoing whose major stock-in-trade appears to be persuasion rather than prediction.

The symptoms of conscious bias, singly or in combination, raise questions as to how far methods and conclusions may have been altered. They may be biased far enough to render them invalid; then again, they may not. The symptoms of bias do not alone provide sufficient justification for rejecting proposed methods, concepts or actions, as we will attempt to illustrate later in this section. They do, however, raise the question.

A discussion concerning conscious bias is not only relevant to forecasting, but also to the consumers or users of forecasts. Today, legislators, commanders, managers, executives and policy planners -- decision makers of all sorts -- are common targets of the hard sell, often seen in the form of biased forecasts. Anyone who makes monetary decisions, from housewives to heads of state, is constantly barraged with proposals for the best way to spend their money in light of "impending conditions." Many if not most of these forecasts are highly biased.

b. Unconscious Bias is a synonym of predisposition, pre-determinism and prejudice. It cannot be avoided anywhere in the normative

realm or in anything that involves human beings: even the desire to do so is itself a bias. However, this latter bias may eventually be validated as less detrimental than some of its alternatives. Most scientifically oriented individuals maintain a bias toward objectivity -- in their professional, but not necessarily in their personal, political or religious affairs. Therefore, the approach to optimizing human data banks is not to be found in trying to eliminate all bias, but rather through drawing on them in the areas where they are relatively least biased. Thus, the initial problem becomes one of identifying such unbiased areas in particular individuals or groups.

However, insofar as data retrieval from human storage banks is concerned, unconscious bias is by far the more difficult of the two, because its holder is not aware of it and implicitly assumes that his own predispositions represent self-evident truth. Again, the humanistic approach is to infer the norm from patterns of observed behavior. It is inductive, it is not certain, but it helps. Some characteristic symptoms of unconscious bias are: (1) sincere advocacy of parochial advantage or point-of-view, (2) dogmatism, (3) self-righteousness and anger at contradiction, (4) a paternalizing attitude toward others' "errors," and (5) ridicule of others' opinions. The parochialisms thus supported or defended may be in reference to the man himself, his family, friends, political party, profession, academic discipline, company, department, branch of service or agency, social class, state, nation, race, ideology, religion, or any combination of these. All of these are identity or loyalty groups, synonyms of "self" at various orders of magnitude. The "universalist" or "world citizen" takes the human race as his loyalty group.

The point here is not that such parochialisms are "bad." They also may show relative utility in the humanistic realm. Loyalty wider than responsibility may lead to cooperation between groups. On the other hand,

loyalty to a group smaller than that for which a man is responsible may lead to nepotism and favoritism. This utility may also be approached through validation of norms.

The point is that unconscious bias and parochialism make attempts to establish an independent base for evaluation of forecasts, proposals and explanations exceedingly difficult. One illustration of this difficulty may be seen in the following quotation.

Ideology constitutes a predicament more insidious than the universal liability of mankind to personal prejudice. (Men) can correct each other on points of personal prejudice, in which one man deviates from his colleagues -- but how can they correct for a pervasive bias that they all may share...? (Ref 47)

This is essentially a monoculture situation, which shows similar characteristics of stagnation in any environment, biological, psychological, or social.

2. Self-Defeating and Self-Fulfilling Forecasts

There has been considerable discussion in regard to the phenomena of "self-defeating" and "self-fulfilling" predictions. (Ref 48) Both are a matter of normative bias. When the bias is applied consciously, they are a form of salesmanship designed to influence human actions. When the bias creeps in unintentionally, it is a reflection of unconscious predispositions on the part of the forecaster, due to his personal, professional, cultural or ideological axioms. The bias itself represents an alteration of the facts perceived, projected, or presented by the forecaster, either toward his positive or away from his negative values.

a. Self-Defeating Forecasts are those designed to minimize a negative value, avoid undesirable consequences, or to prevent their own conclusions from coming into reality by persuading human beings in a prescribed direction.

One example of a self-defeating forecast, in which perceptions and projections appear to be objective, while methods of presentation have frequently been weighted to transmit the urgency of projected conclusions, is the "population explosion." The prediction, "If birth rates are not substantially reduced, massive starvation, social, economic, political and moral collapse will be widespread by the year xxxx," is a normative projection. The forecaster is obviously biased against starvation, social, economic, political and moral collapse, and thus in favor of reducing birth rates. If he were not so biased, he would not bother to advertise his findings; he might not even bother to investigate. He feels his projected conclusions bode great loss to himself and to his own loyalty groups, and that acceptance of his proposed actions will aid in averting such loss. He is neither dispassionate nor uninvolved. Therefore, his forecast is designed to be self-defeating; nothing would make him happier than to have subsequent reality prove him wrong. He sees little value in being able to say, "I told you so."

In many areas of the world, the characteristic inertia of human beings, or doubts as to the validity of demographic projections ("They're always crying 'wolf'. Look at how often they've been wrong. Why, in the last US census, they missed over five million people when they tried to count them. How can you believe forecasts like that?") combined to reject the demographers' predictions. Little or no action was taken. Today, in some of those same areas, such delays are showing signs of negative utility to the point of disaster: the validity of demographic predictions is being pragmatically -- and expensively -- confirmed.

On the other hand, a few countries -- like Japan and Taiwan -- accepted the projections, biased or not. Their massive change of behavior has made forecasts of disaster progressively unrealistic. If the similar disasters projected for India, China, Latin America and

subsequently the rest of the world do not come into reality, much of the credit must go to the self-defeating forecasts of those demographers who emphasized their presentations to make people fully aware of what might have happened. Under these circumstances, it would be the height of ingratitude to accuse them of inaccuracy on the grounds their projections of future population levels had been too high.

A second example of self-defeating prediction -- and one that has many corollaries -- was that of the unknown general officer who stated: "If the strength of our present armed forces is not maintained, national existence will be in jeopardy." In this case, the conclusion was accepted and actions designed to prevent its coming into reality brought the country's cavalry units to a peak of excellence. However, the forecast was demonstrated to be not only biased, but invalid as well, when Poland's superb horsemen were slaughtered by German tanks and dive-bombers in the opening days of World War II.

b. Self-Fulfilling Forecasts are those designed to maximize a positive value, obtain desired conditions, or to ensure their conclusions are realized by persuading human beings to alter their actions in a prescribed direction.

One example of a self-fulfilling forecast is found in the technologies of food production. Glowing prophecies of exponential increase (provided the suggested techniques and allocations are followed) show how the human race may be freed from starvation, and attain to the nutritional millennium. Hopefully, people will heed the proposals, explicit or implicit, of these forecasts, alter their patterns of behavior, and so attain the desired result. Again, the forecaster is neither dispassionate nor uninvolved.

In some cases where such forecast/recommendations are heeded, food production is being increased by many times. The assumptions

behind both forecast and recommendation are being demonstrated as valid. In other cases, actions based on such recommendations are not working, due to application of techniques where they are not relevant (plowing under the jungle in Brazil), and to unconsidered humanistic values (sacred cows in India).

A second example of self-fulfilling forecasting is found in the political arena. From Sir Winston Churchill's "We will fight on the beaches; we will fight on the housetops; we will never give up" to the less significant parallels of every political campaign, forecasts of coming victory are designed to so move human beings as to attain the forecast condition.

A good deal of technological forecasting and advertising of the producers of technology is also of the self-fulfilling character. It is again a form of salesmanship.

Two final examples of biased forecasts are the typical predictions in regard to nuclear war. One school holds the human race will inevitably destroy itself (unless all such weapons are permanently banned), and the other school concludes these weapons will never be used again (because all parties will or ought to realize they stand to lose more than they stand to gain by employing them). Both are biased forecasts; the first designed to be self-defeating, the second to be self-fulfilling. Here, the steering-signal nature of normative projection is apparent, with its characteristic positive and negative directives for human behavior. Biased forecasts are less in the nature of predictions than they are in the nature of covert prescriptions.

3. Validation of Biased Forecasts

Validation of biased forecasts presents humanistic problems, because they do not necessarily correspond to either present or future reality. This is why they cannot be validated by the realistic or natural

science approach. However, actions based on either acceptance or rejection of such exhortations can and do alter the future condition. Whether this resultant condition is "better" or "worse" depends on the value-system of the observer. Finally, when actions are based on a biased projection, the question of whether or not they achieve their original purpose depends on the validity of assumptions concerning potential reality on which the projections were based.

Thus, the imperative question raised by indications of bias is not whether it exists -- all humans are biased in one way or another -- nor if methods of preparation or presentation have been slanted. The only pertinent question is whether the conclusions are valid indications of potential reality. Since potential reality depends to a high degree on human decision, we can see the value of a good manager's habitual question: "What happens if we do, and what happens if we don't?" This is the core question of empirical validation in the normative realm. Its utility lies in elimination of bias and concentration on potential consequences of decision.

For the above reasons biased forecasts are classified as both normative and as problems of validity. Like any validation, Validation of Norms -- past, present or proposed -- calls for the tentative assumption of a premise or premises (we do, we do in part, we don't), and rigorous deduction to logical consequents. In this case, the premises are proposals for action, and the consequents are, (1) implied behavior, and (2) the potential results of such behavior. Evaluation of these results, when compared for all proposals, provides the basis for deciding between them.

The validity of normative proposals which may be obtained in this way shares the uncertainty characteristic of any validation; it cannot be absolutely ascertained. The procedure is capable, however, of

significantly reducing both bias and uncertainty, while at the same time minimizing the cost of error. Thus, it can supply an improved information base for normative or policy decisions.

a. Validation to Reduce Conscious Bias recalls one characteristic of validation which may be ignored only at considerable risk. This is the requirement for an independent data base. In the normative realm, a good deal of the data base is carried in human minds; therefore, for the validation of norms, the test base people must be independent of the original bias. Here, independent means exactly that: neither positively or negatively covariant, geometrically orthogonal in attitude, unpredisposed, free of prejudice, etc. Obviously, such paragons do not exist. Therefore, optimization is indicated.

The question here is to whom one should send a biased forecast for evaluation, and it leads to several inherent problems. In the first place, it makes little sense to send a proposal back to its originators for evaluation. Secondly, it makes no more sense to send it to their opposition, where it will be denied out of hand by a counterbias. Third, there is little use in sending a proposal to someone who should have thought of it by himself, and fourth, evaluation by the target decision makers themselves is risky, since it was toward their assumed biases that the originator slanted his presentation. Such problems indicate why independent evaluators and evaluation agencies are in high -- and increasing -- demand. It is also why a decision maker does himself little favor when he insists his own biases be shared by his evaluators. He either sets them up for the same "snow job," (normatively biased presentation) that he himself received, or at the very least prevents them from forwarding unbiased reports to him.

Conscious bias is best eliminated by employing an independent agency, and insisting their findings be based on a replicable method such

as the one presented in the appendix of this report. While such a method will include the values of various human institutions as a means of ascertaining relevance, it validates facts and predictions against empirical evidence, rather than against parochial desires.

b. Means of Reducing Unconscious Bias are somewhat different, because this will be found in an independent evaluation agency as well as in a parochially involved forecaster. Unconscious bias is a matter of profession, academic discipline, culture, etc. What is lacking in such a pervasive bias or monoculture is negative feedback, here seen as dissent. The indicated corrective action is diversification. In this case, it is diversification across the departmentalizations. A second requirement is mutual exchange, here seen as dialogue. The former is necessary to obtain more than one bias, and the second is necessary to cancel or reduce differing biases. This is comparable to the natural science procedure of employing multiple sensors with varying distortions, and then correlating the observations to obtain a broader and more accurate view.

As with any monoculture problem diversification is a precondition of dynamic exchange. Interpersonal, intergroup, interparty, interprofessional, interdiscipline, intercompany, interdepartment, interservice, interagency, interclass, international and interdenominational dialogues are symptomatic of dynamic feedback in operation at the verbal level.

The alternative to verbal and behavioral dialogue is verbal and behavioral dialectic: intergroup rivalry, self-maximation by opponent reduction, various collisions and forced adjustments. Here, feedback is delayed by lack of willingness to accept it, until it is eventually imposed. Withdrawal from the exchange (isolationism) is an alternative when available. This leads back to stasis and the "bacteria in a bottle" problem of the monoculture.

However, diversification and dialogue are not a magic answer either. Although they hold great long-run promise, they have definite problems in the short run. Feedback implies friction, in the humanistic realm as in mechanics. Courtesy -- social oil -- helps. One example of the problems monoculture parochialism presents, and those of two alternative attempts to counter it, may be seen in the increasingly common efforts toward integrated research and forecasting.

(1) Monodisciplinary studies are by far the easiest to organize and conduct, especially if placed in one department at one university, one industrial, nonprofit or military laboratory. A great deal of excellent work has been and is being done in this way. However, monodiscipline studies are becoming progressively less useful because of two inherent problems.

First, whenever a problem is analyzed or interrogated, it follows conical organization by expanding to such a degree that no one discipline is able to cope with it. A selection of only those subproblems which remain in the context of the original discipline is the approach of specialization: it discards the remaining factors of the problem. However, it is exactly those factors eliminated from consideration by the very definition of a discipline whose unaccounted-for influences feed back in over time to render a forecast ineffective. This phenomena was also discussed previously.

We have already seen how specialization impairs technological forecasting when it does not take human factors into account. The same thing holds true for other disciplines. In the social sciences, how can International Relations be studied or projected with any accuracy if the natural, social, cultural, technological, economic, biological, and psychological components of individual nation-state "actors" are defined out of consideration? How can one project the course of economic

development without study of natural resources, geography, climate, local ecology and agriculture, demography, cultural attitudes toward forms of labor, state of technology, local political philosophy, family structures, and the taboos of indigenous religions? As one area specialist remarked while discussing the future of India's economy, "Those sacred cows have got to go!"

His comment also illustrates the second major problem of single-discipline study and projection; each discipline has its own sacred cows: axioms, self-evident truths, standardized procedures and habitual patterns of thought or attitude. Some of these have been repeatedly confirmed and demonstrate high degrees of predictive power; others have such power only in specific cases, but have been overgeneralized; still others appear to have held greater power in the past, before reality altered away from their implicit assumptions. A number of such axioms have been empirically or pragmatically denied, but continue to show up in forecasts and forecasting methods.

For one example of such empirical denial, many forecasts of international conflict and cooperation are based on the assumption that present or historical patterns of formal alliance are the best indicators. However, two independent empirical studies, one by Bruce Russett (Ref 49) and one by Ole Holsti and his associates, (Ref 50) both support convergent and conflicting attitudes as lead indicators of behavior and subsequent formal alliance, rather than the converse. In other words, alliances are a result, rather than an adequate precursor of conflict and cooperation.

It is extremely difficult to attack one's own self-evident truths while within the rationale that flows deductively from them. This applies whether we are speaking of personal attitudes, political philosophy, religion, or academic discipline. It also illustrates the value of empirical reasoning, which questions the validity of entering assumptions,

eliminates sacred cows, and synthesizes more general and more valid theory. It does not solve problems directly, but refines the mental tools by which the rational modes may subsequently solve problems. Until their mental tools are tested and refined, many disciplines and sub-disciplines must remain at something akin to ethnocentrism, wherein their own axioms are sacrosanct, and others' appear to be irrational. The end result -- apart from a continuing profusion of micro-specialities -- is that the relative validity and bias of such opinions is well-nigh impossible to ascertain, forecasts are inaccurate for exclusion of significant factors, human data bases for validation are themselves suspect, and decision makers are left guessing.

(2) Multidiscipline. When we attempt to bypass the restrictions of single-discipline study, the first move is normally toward aggregation rather than integration. We find that segments of our problem belong to fields studied by certain disciplines which we do not have available, so we introduce experts from these fields into our organization. However, we do not establish a feedback dialogue across disciplines, but rather operate within disciplinary compartments like a micro-university. What actually occurs is that individuals whose backgrounds, frames of reference and terminology allow them to understand each other congregate in one office or section, study the common task, and eventually come out with a specialized report. Such reports are then merely collected and published. For these reasons, most projects nominally referred to as "interdisciplinary" might be more accurately described as "multidisciplinary."

If, on occasion, a project manager attempts to synthesize such a battery of reports, he either rewrites them all in his own terminology -- thus destroying a good deal of the intended meaning -- or simply finds himself swamped by the necessity of learning a dozen or so new

languages all at once. In this case, he is likely to write up his own summary, and attach the specialized reports as annexes or appendices. This is very common practice.

Thus, the primary characteristics of multidiscipline studies are: (1) absence of feedback between departments or disciplines, (2) specialized sub-reports or annexes, (3) duplication and overlap of the same areas from various points-of-view, and (4) little if any integration of effort. This approach to forecasting and evaluation of forecasts generally tends to compound the problem, rather than simplifying it.

(3) Interdiscipline. True interdisciplinary study shows self-correcting characteristics, primary among which is continual feedback between individuals, departments and disciplines. A common symptom is the face-to-face confrontation of individuals representing a number of specialities, all focused on and attempting to solve a common problem. Forecasting has provided many such problems.

One immediate characteristic of feedback confrontations is the semantic argument. Everyone -- or almost everyone -- firmly believes he is speaking the English language. He understands perfectly well what he is saying, but no one else seems to. Nor do the assertions of other team members make much sense to him. They use the right words in the wrong places. In these situations, the trite comment that "It's only semantics..." is a gross oversimplification. Semantic arguments imply fundamental differences in point-of-view, modes of reasoning, basic assumptions, terminology and values. The difficulty of trying to establish meaningful communication across such deep-set barriers may be compared to the similar problems faced at the Tower of Babel and the United Nations. Even when -- as usually happens eventually -- two people discover they have been saying the same thing all along, the process by which this revelation is obtained is seldom easy. Hence the inscription over the door of one such interdisciplinary forum: "The Citadel of Violent Agreement." (Ref 51)

Another symptom of interdisciplinary study -- and empirical processes in general -- is a constant, grinding reappraisal of one's own self-evident truths and fundamental axioms. One of the primary purposes of such diversification across disciplines and departments is to increase objectivity by reduction and cancellation of unconscious bias. The high value of the process may not be so apparent, however, when your own unconscious biases are attacked, and your own sacred cows are dragged out to be dispatched. It can be, in fact, a highly painful and traumatic experience. If one does not maintain extreme mental flexibility, an iron emotional restraint, and at least the rudiments of courtesy, the atmosphere in a "Citadel of Violent Agreement" is very likely to become exponentially more violent over time, with agreement, integration and accomplishment following by inverse proportion.

This then, is a not greatly overdrawn sketch of interdisciplinary study and empirical processes. It is not intended to imply that such efforts are impossible. On the contrary, it is merely to point out that they are seldom easy, often extremely difficult, characteristically uncertain, and personally unsettling. With all of these problems, however, the products which only such a process is capable of delivering: more valid theory, more general premises, wider data base, reduction of unconscious bias, penetration of barriers between departments and disciplines, and removal of sacred cows are vitally important to the progress of organized knowledge in general and to the improvement of forecasting in specific.

4. Summary

The matter of "self-defeating" and "self-fulfilling" predictions, while a large and ever-present problem in forecasting, is not completely beyond remedy. Some bias, conscious or unconscious, is always to be expected, and does not by itself constitute adequate reason to accept or

reject any forecast, because examples of both have proved to be valid and other examples invalid. Where such bias is no more than salesmanship, it may be detected and reduced by the use of independent evaluators. Where it is due to academic, departmental or cultural axioms, the use of multiple sources with diverse points of view is indicated. Personal bias is amenable to the same approach of diversification and dialogue. While none of these techniques can be expected to eliminate biased forecasts altogether, their combined application may serve to reduce the problem significantly.

VII. POTENTIALS FOR INCREASED EFFECTIVENESS

Since the purpose of this study is to assist in the continuing improvement of forecasting, a survey and synthesis of philosophical considerations is inadequate. The foregoing sections have set a stage and identified strengths and weaknesses characteristically involved in the process of forecasting. This section will attempt to organize these into a critical path network designed to maximize strengths and minimize weaknesses, thus indicating potentials for immediate or near-time improvement. It will also attempt to match strength and weakness where possible as an indication of potential avenues for more distant but continuing improvement of the process and the product.

Near-future improvement potentials may be viewed as application opportunities; the more distant as basic research opportunities or requirements.

As discussed previously, the two characteristics of an effective forecast are reliability and relevance (Figure 13). Reliability refers to the power of prediction or level or expectable confidence, and relevance refers to the relationship between subjects selected for projection and the needs of specific planners and decision makers. Because both of these are necessary, and neither is sufficient for effective forecasting,

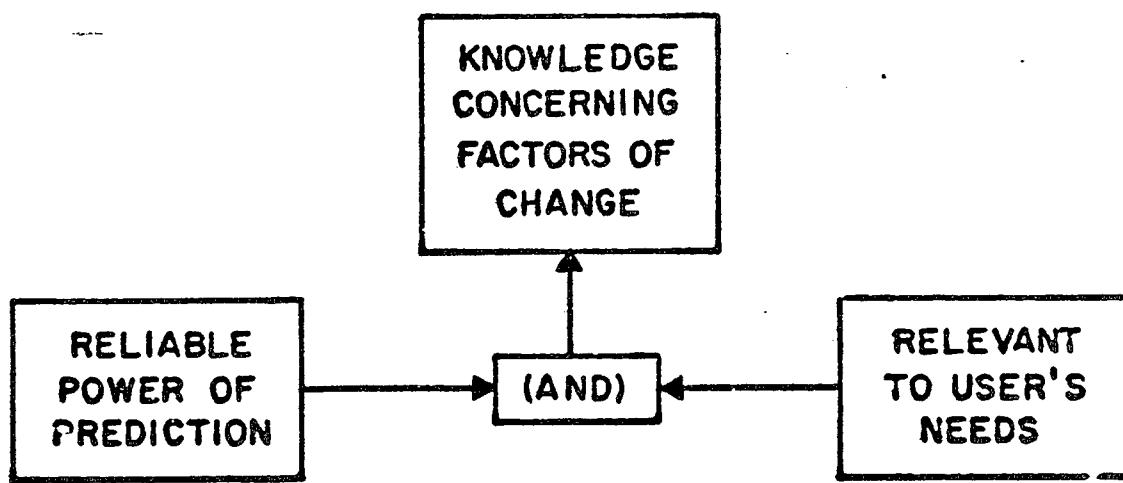


Figure 13. Characteristics of an Effective Forecast

both must be improved. However, since their characteristic strengths and weaknesses also differ, their improvement must be approached separately.

1. Improving Reliability

Reliability is a relative measure, varying from sheer guess-work and superstition to high-quality scientific prediction. The degree of reliability required of any given forecast depends on the criticality of the subject in terms of its value to specific planners or decision makers. Thus, both the acceptable level of reliability and the directions or subjects in which improvement is needed is a matter of relevance, while this subsection deals only with the problem of how it may be done.

There are two underlying factors which contribute to forecasting reliability in any given area. These are the consistency of logics and the validity of premises (Figure 14). Again, both are necessary and neither is sufficient to provide the power of prediction. However the relationship between these factors is not symmetrical: logical consistency may raise reliability up to, but not beyond, the validity of entering assumptions, while logical fallacies merely reduce reliability below that level.

a. Improving Logical Consistency

Although evidence of logical fallacies is quite common in the speculations which now saturate much of the public news media and popular press, this study has found very little of it in the more serious or professional forecasting methodologies. Apparently this is because the rules of formal logic provide adequate criteria for ascertaining consistency in both the preparation and evaluation of forecasting methods. They are widely available in texts on philosophy, (Ref 52), and it would seem most serious forecasters are applying them. Almost without

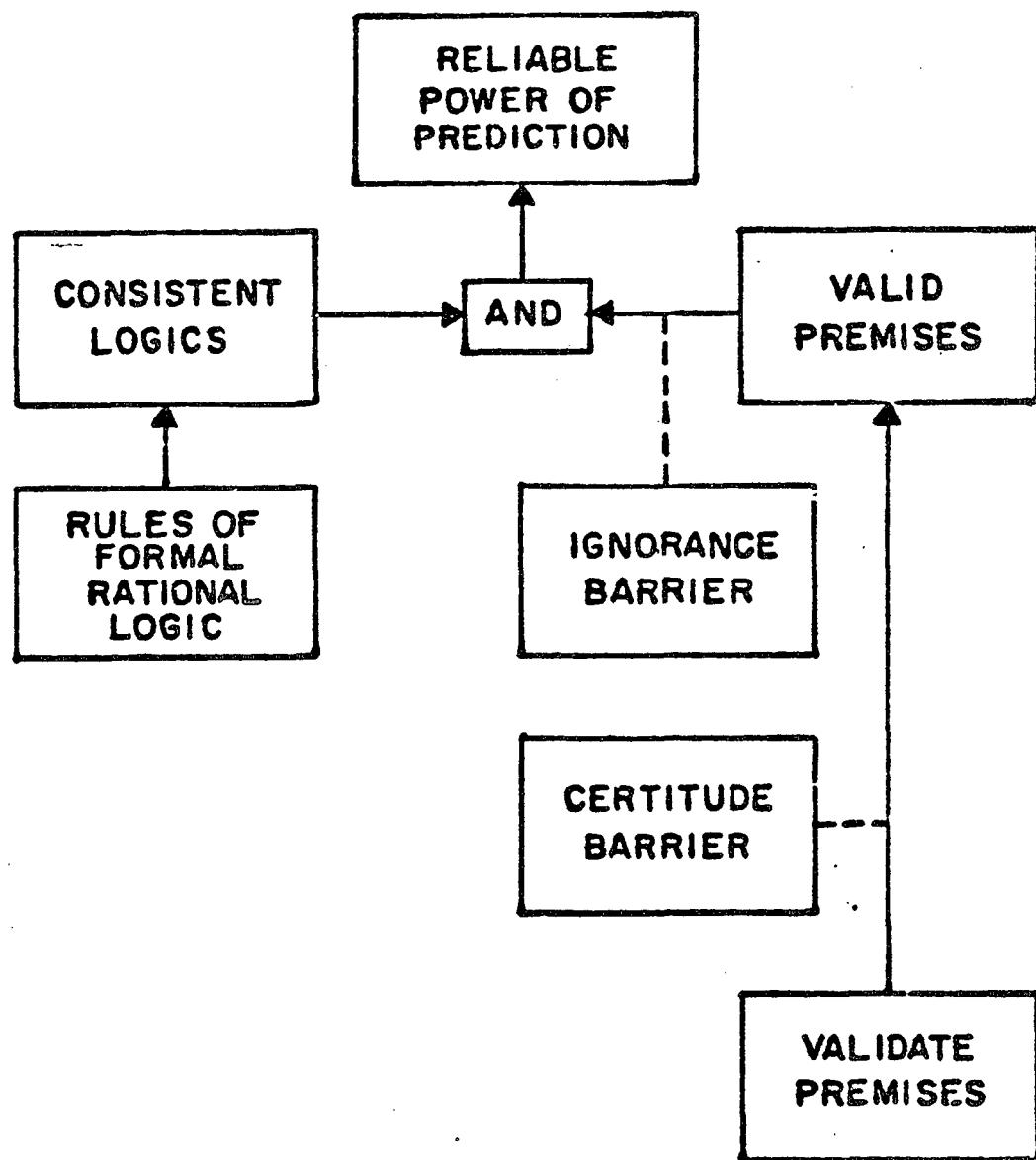


Figure 14. Factors of Reliability

exception, such efforts meet the criteria of formal consistency; their predictions are necessary consequents of the premises employed.

b. Improving Validity of Premises

In contrast with the consistency of logics, there is considerable evidence in both professional and nonprofessional forecasting that premises are invalid. Many highly sophisticated, mathematized and computerized forecasting methodologies are being fed input assumptions which are at best highly questionable, and in some cases empirically denied. This is not a rare occurrence, but is extremely common. (Ref 53) Lack of awareness of recent empirical research is often a contributing factor; old assumptions have been demonstrated as false, but the forecaster does not realize it and continues to apply them for projection. In other cases, a forecaster working outside his own area of expertise intuitively reinvents concepts long since abandoned by those more thoroughly acquainted with the field.

However, lack of information and intuition are only barriers to present forecasting reliability; they are not of themselves barriers to its improvement. The primary barrier to the improvement of forecasting reliability in this and many other areas stems from exclusive reliance on the rational logics.

While the rational logics are necessary in forecasting, they require the operational assumption of certainty (or of known statistical probability), and so do not directly investigate the validity of premises. When this assumption becomes habitual rather than only operational, individuals and institutions also fail to investigate the validity of their premises and so continue to assert projected conclusions as though the premises were valid. This is certitude. It precludes the improvement of validity, and so of forecasting reliability and effectiveness. As Alfred North Whitehead states it:

The history of thought is a tragic mixture of vibrant disclosure and deadening closure. The sense of penetration is lost in the

certainty of completed knowledge. This dogmatism is the anti-Christ of learning. (Ref 54)

Thus, whenever the available premises will not adequately explain the past or present, have repeatedly failed to predict the future, or lead to multiple competing and conflicting assertions, the utility of a rational approach becomes zero. There is no benefit in further acquisition or projection of invalid concepts.

(1) Prerequisites of Validation are based on the nature of the barrier. Because certitude is nothing more than an habitual pattern of thought, the barrier may be broken simply by assuming one does not know. In this case, the assumption of ignorance (or humility), means questioning the validity of one's own assumptions and the premises he intends to employ for projection. Once this is done, two alternative means of establishing validity become available. These are submission to authority and submission to evidence (Figure 15).

(2) Submission to Authority is the rational logic earlier denoted as authentication. Rather than assuming that we ourselves know something with certainty, it assumes that someone else does. Thus, this approach to validity merely sets the problem back to the authority, and so has definite limitations. Because the authority itself must have previously met the requirements of empirical validation (submission to evidence), only in those cases where axioms or experts have been thoroughly tested and supported by a proven ability to predict does submission to authority escape its two unacceptable alternatives. These are (1) having to accept the authority on faith alone, or (2) submission to higher and higher authorities, an infinite regress that leads to a dead end. In all other cases, empirical rather than rational validation is the avenue for improvement.

(3) Submission to Evidence is the empirical logic of verification. It has a specific set of requirements (Figure 16).

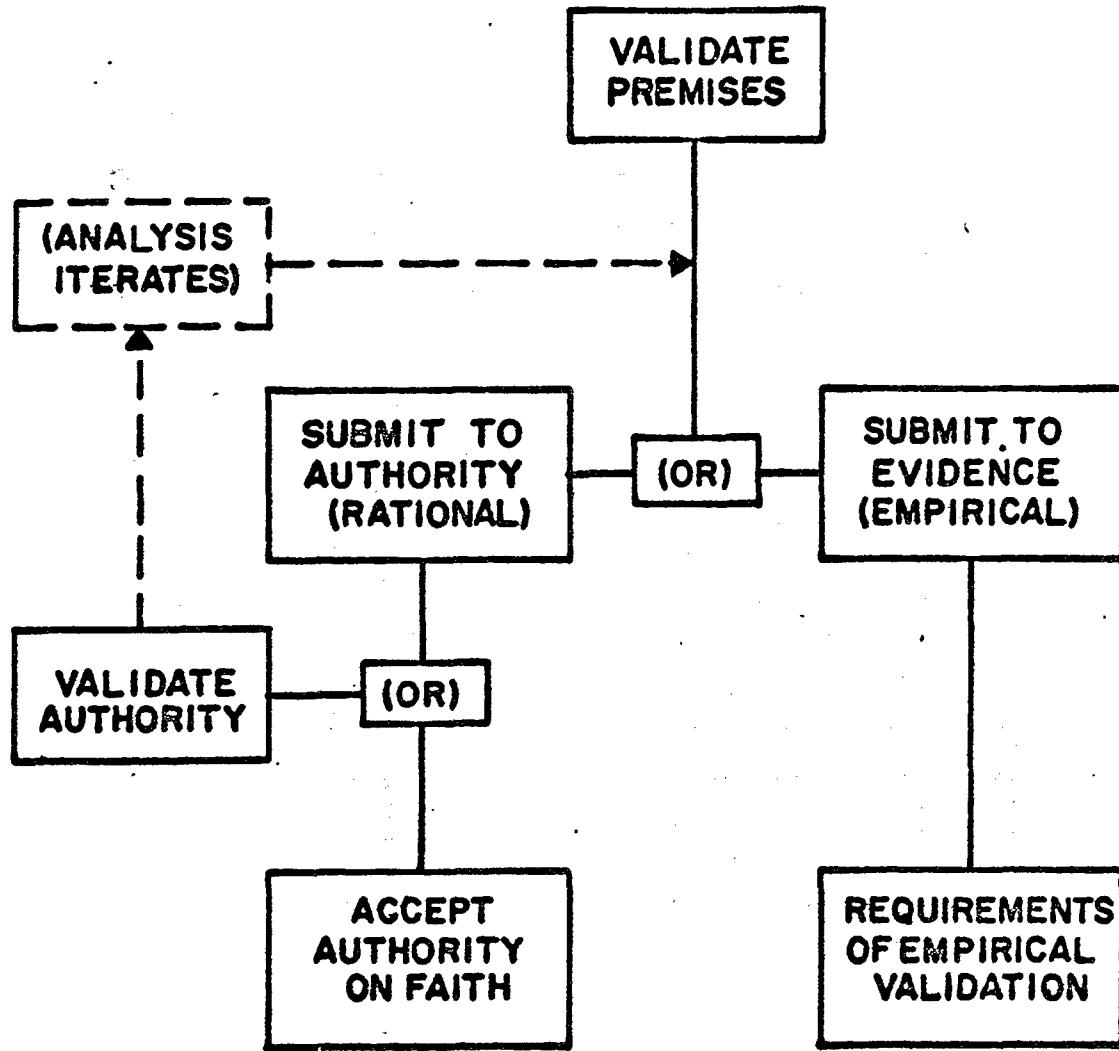


Figure 15. Alternate Means of Validation

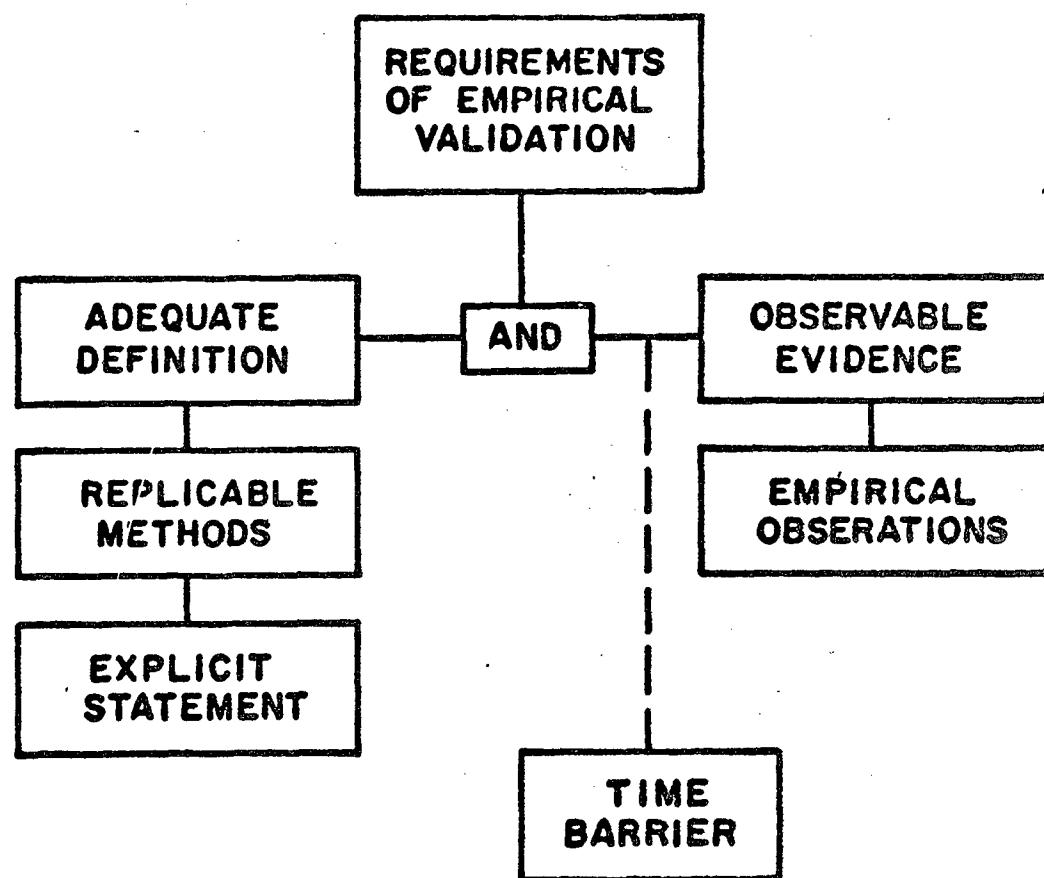


Figure 16. Requirements of Empirical Validation

(a) Adequate Definition of the premise to be tested is necessary in order to determine what evidence will be required and what sorts of observations will constitute affirmation or denial. This is why vague, ambiguous and overgeneralized premises cannot be verified; they do not adequately define the conditions to which they do and do not apply (limits), and the specific evidence required. Thus, their validity is indeterminate (untestable).

The same limitation is found in non-replicable methods which disguise or hide their assumptions, and in the implicit assumptions behind more replicable methods. They also make validity indeterminate. These associated problems are quite common in some areas of forecasting, but they do not appear to be universal. The avenue for improvement is, of course, in more rigorous definition and explication.

(b) Observable Evidence is also necessary for empirical verification because even in those cases where premises do adequately define the requirements, if no evidence is available, validity is still indetermined (untested). Both verification and basic induction require compilation of extensive data bases from empirical observations. Lack of such bases is a major barrier in some areas of forecasting, and data collection is a prerequisite of improvement.

It is the requirement for observable evidence which sets the stage for the one problem of forecasting most often considered to be unique. Empirical validation may test either premises or their deductive consequences against observed evidence. The latter is the more common approach, and is required when premises refer to nonobservable phenomena. In forecasting, all predictions are themselves the deductive consequents of dynamic premises, and testing them against observed evidence is the primary means of verifying those same premises. However, predictive consequents refer to future conditions, and a major

characteristic of future time is that it presents no observable evidence. This mandatory requirement for evidence which is not available we have called the "time barrier."

(4) Alternative Means of Avoiding the "Time Barrier" are available through the same techniques employed in other fields of inquiry dealing with nonobservables (Figure 17). Such techniques involve analyzing the problem to determine points at which observations are possible. In the case of forecasting, all observable points lie in the present or past, where evidence is at least potentially available. Two means of employing such evidence derive from the pragmatic and the experimental approaches to verification of dynamic premises.

(a) The pragmatic approach is the more common and in many cases the more efficient of the two. It simply involves making one or more predictions, and then waiting for the passage of time to bring relevant evidence into the present where it can be observed, compared with the predictions, and so used to affirm or deny the premises behind those predictions. Much of the progress in the natural sciences has been accomplished in this manner, and some writers on the problems of forecasting have maintained there is no other way to validate any prediction. Many writers also imply such verification is absolute. However, in order to establish absolute validity, one would have to test all possible consequences against all possible evidence; it cannot be attained as long as either remain unaccounted for. In the case of dynamic premises used in forecasting, neither evidence nor consequents are exhausted so long as time and change continue. This is why no forecast is -- or can be -- absolutely certain. Once it has become certain (as either true or false) in one specific instance, it is no longer a forecast. When the same premise is employed again for another prediction, that prediction will again remain uncertain (by degree) until it is no longer a prediction.

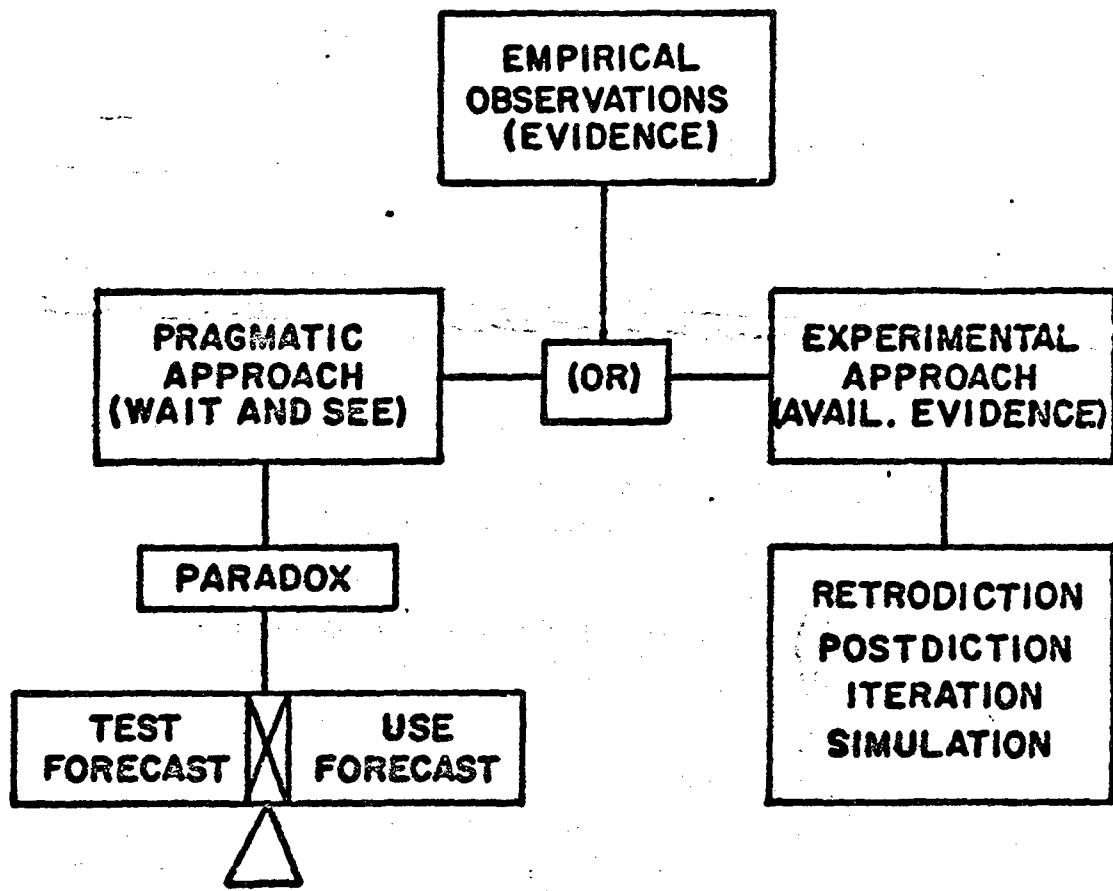


Figure 17. Alternative Means to Avoid the "Time Barrier"

For this reason, the pragmatic or "wait and see" approach is not advisable in the case of long range forecasting or the forecasting of critical subjects. It contains an inherent paradox, in which the evidence necessary to determine whether a forecast is reliable or unreliable will arrive simultaneously with the situation that same forecast might otherwise allow planners to avoid.

If the forecast is made known to planners in advance, and they base decision and action on it, this will alter the future condition by the degree to which their actions are successful. In this case, there is no way of telling what might have happened, and so no way to adequately test the forecast. A few writers have suggested this side of the paradox be avoided by locking a forecast away in a vault until its time period has expired, thus providing an unbiased validation. This would, of course, make the forecast entirely useless for planning.

It appears that under the "one-shot," "wait and see" approach, one may either increase the reliability of a forecast by testing it, or its relevance to planners by using it, but not both. However, study of the logics involved in forecasting indicates another alternative which bypasses both the "time barrier" and the "wait and see paradox." This is through experimental rather than pragmatic validation.

(b) The experimental approach to verification of dynamic premises employs the logical identity between prediction, explanation and retrodiction. Essentially, it so utilizes the time function of such premises as to make their logical consequents fall into the past or present. This approach is very common in the research community, where experimental testing has long been recognized as necessary. It is also being applied on an ad hoc basis in a few forecasting projects. Specific techniques are:

. Retrodiction, or projection backward over time. This is especially useful for testing the hypothetical time functions produced by regression

analysis and employed for extrapolation. Presently, such time functions are often not tested against evidence other than the data from which they were obtained. Retrodiction may also be used for testing analogies, by taking a present condition as final stages and working backward to the earlier symptoms. Here, one tests an analogy by retrodicting what the symptoms should have been, and then looking in past records for evidence of those symptoms.

Postdiction is projection from the more distant to more recent past or present. In the latter case, it is often referred to as explanation, the assumption being that adequate explanation of the present condition implies the power to have predicted it from an earlier period. This technique is more common than retrodiction, and is applied to both extrapolations -- by withholding the later portions of a data base as evidence by which to test the function -- and to analogies. In the latter case, one postulates what past symptoms should have led to, and then checks to see what they actually led to in the more recent past.

Iteration of frequent short-term verifications is a compromise technique that avoids the hazards of "one-shot" long range forecasting by shortening the wait for evidence. It is more useful when applied to trends than to analogies, and while it does not avoid the reliability-relevance paradox in the short run, it does reduce it significantly in the longer run.

Simulation is another useful technique, if parameters are clearly defined and the analogy between laboratory and real world is tightly drawn. It acts to reduce the cost of mistakes by taking the risk into a less critical environment. It also may serve to artificially accelerate the passage of time, making simulated evidence available more quickly.

c. Criteria of Reliability

After reasoning our way through the maze of barriers, mental and natural, which underlie the power of prediction, if we

successfully avoid the several philosophical dead ends, we arrive at four main requirements. Two of these relate to logical consistency, and two provide an indication of validity. Together, they represent useful criteria for the preparation or evaluation of forecasts.

(1) Methods Must be Replicable, because if they are not there is no way to determine either consistency or validity. This does not mean that non-replicable methods such as prophecy, intuition and expert judgment are incapable of delivering reliable forecasts, but only that there is no way to evaluate them in advance. If an individual expert has a long record of successful intuitions, one certainly has increased justification for expecting better than average success in the future; however, this is more akin to faith than to hard evaluation.

(2) Logics Must be Formally Consistent. While most forecasters and evaluators of forecasts are not formally trained as logicians, they are accustomed to rigorous thinking, and are quite capable of spotting the more obvious fallacies. When a particular method is to be employed over an extended period or for highly critical subjects, additional evaluation by formally trained logicians may assist in disclosing the less obvious fallacies.

(3) Premises Must be Explicitly Stated and Adequately Defined. The digging out of implicit assumptions is one of the most time-consuming but essential steps in evaluating forecasts. However, if they are not disclosed, they and those portions of the forecast based on them are of indeterminate validity. Vague, ambiguous and overgeneralized assumptions also make sections of a forecast indeterminate.

(4) Premises Must Have Been Tested and Supported by Experimental or Past Pragmatic Validation. In this area, a thorough awareness of -- and continuing contact with -- research efforts in the empirical testing of relevant concepts is essential for both the

preparation and evaluation of forecasts. Degree of validation is the most vital of these criteria, and further empirical research is the primary avenue for improvement for forecasting.

d. Pseudo-Criteria of Reliability

(1) The Type of Display Technique Employed -- whether this is oral, written, mathematical, computerized or graphic -- holds little correspondence to the reliability of a forecast. Personal preference for a given technique has led some forecasters, evaluators, planners and decision makers to assume it also implies greater reliability. Several surveys have differentiated between "forecasting methods" almost entirely on the basis of display technique.

(2) Sophistication of Method. There appears to be an assumption in some areas of forecasting that the degree of mathematization or computerization is a measure of reliability. Much of the present debate between the so-called "quantitative" and "qualitative" schools derives from this assumption and its opposite. Both tend to overlook the fact that mathematics is no more than a very concise and precise language.

(3) Certainty or Confidence Implied by a forecast is not a criterion of its reliability because all projections are deductive consequents and deduction implies certainty whether or not this is justified. Fallacious reasoning from invalid premises still terminates in statements of invalid "fact."

(4) Longevity of Axioms and Reputation of Authorities as criteria of reliability stem from the implicit assumption they have "withstood the test of time." The critical factor here is not the length of time, but the degree of testing. Both axioms and experts have stood over time solely because they were not tested. (Ref 55)

(5) Indications of "Self-Defeating" or "Self-Fulfilling" Bias are not a sufficient reason for accepting or rejecting those conclusions.

Both "self-defeating" and "self-fulfilling" predictions have proved to be reliable; examples of both have also proved to be unreliable.

(6) Depth of Analysis and Detail of Argument or illustration are inadequate criteria because they may represent only a large number of subsets deduced from one invalid premise. The fineness of calculation and the number of places to the right of the decimal in statements of probability or correlation are inadequate criteria for the same reason.

(7) Plausibility is perhaps the most common criteria for evaluation of forecasts. Several projects now derive projections mathematically or by computer, and then systematically route them through panels of experts for a plausibility check. The process follows the logic of authentication; the evaluator or evaluators classify forecast conclusions as plausible or implausible by reference to their own a priori understanding, which is assumed to be authoritative. In less formal evaluations, the decision maker himself reviews the forecast and reaches a conclusion in regard to its plausibility, based on his own experience.

This is a useful but inadequate approach; useful, because it may back up areas overlooked by the forecast and catch either wild speculation from loose analogies or blind extrapolations; it is inadequate, because it limits the criteria of reliability to what the evaluator already believes. If a forecast tells us no more than we already know, it is rather a waste of time; if it does tell us more than we now believe, it is apt to be judged as unbelievable, or implausible, and so rejected.

2. Improving Relevance

As previously discussed, the relevance of anything may only be determined by its position in a given set of human values. The reason a particular set of values must be specified is because human values are not universal; the same situation or set of facts may represent a positive

value or "good" to one corporate actor, and the exact opposite to another. Thus, the first requirement of improving relevance is to identify not only positive and negative values, but the actor who holds these values (Figure 18).

Very few modern forecasting operations are purely academic or scientific activities; they are initiated and conducted specifically as a means of providing decision information for the planners and executives of an agency, corporation, military command or national government. Thus, the relevant subject areas are those from which these particular planners need forecasts, and it is the mission of that specific organization which will determine their criticality.

While it is impossible to list relevant subject areas without indicating the needs of a particular actor, it is appropriate to discuss the characteristic needs of planners and decision makers in general.

a. Characteristics of Normative Correlation (Planning and Decision Making) (Figure 19)

Both planning and decision making are normative activities; that is, all plans and decisions are made by correlating knowledge of facts with knowledge of values. What is must be weighed against what ought to be, and what can be done is balanced against what should be done.

By use of economic terminology, a number of factors pertaining to knowledge of values may be subsumed under their more general equivalent, demand. These include such considerations as ends, objectives, requirements, etc. Similarly, knowledge of facts pertaining to means, capabilities, resources, etc.; may be clustered under the term supply (Ref 57). Knowledge of both demand and supply factors is required for optimum decision, but neither is sufficient because of the characteristics of their correlation.

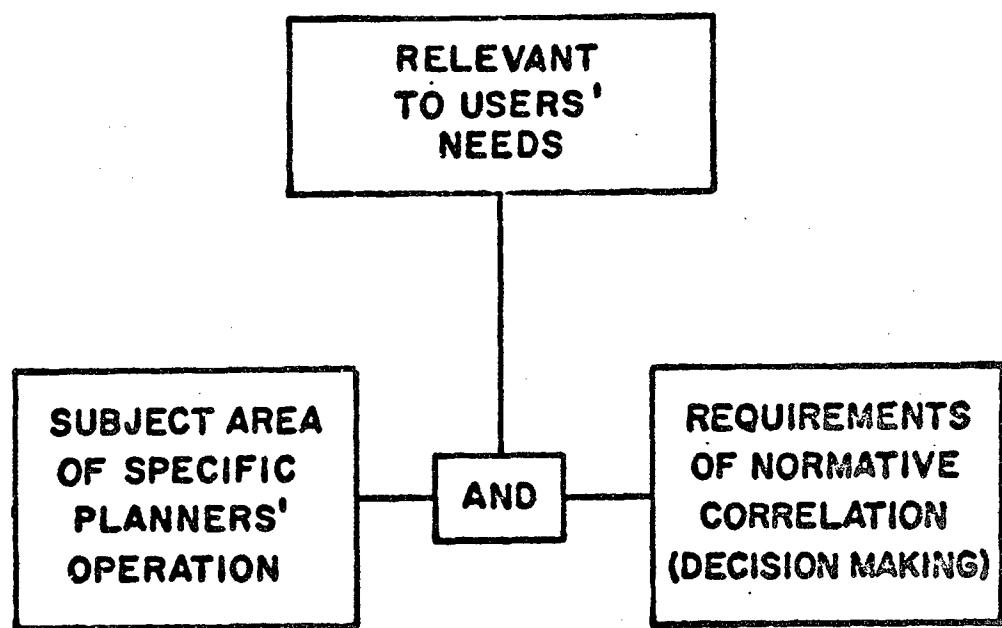


Figure 18. Factors of Relevance

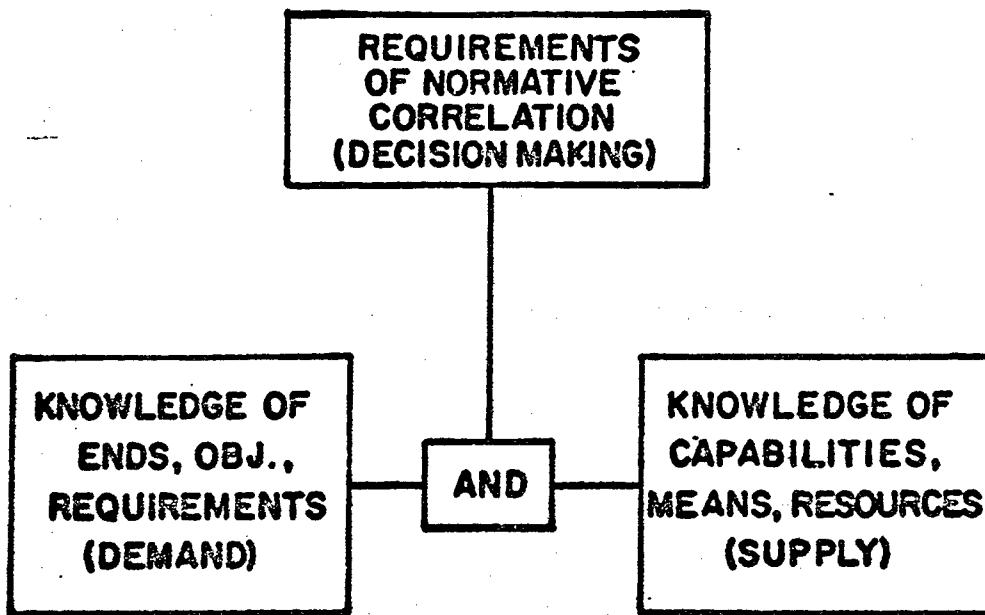


Figure 19. Requirements of Decision

Demand information determines the relevance of any means, capabilities or resources, present or future. Where demand information is lacking or invalid, the relevance of any supply is indeterminate.

Supply information determines the practicality of any ends, objectives or requirements, present or proposed. Where supply information is lacking or invalid, the practicality of any demand -- or of any policy based on demand -- is indeterminate.

For example, a forecast is designed to supply information demanded by a particular set of planners. The forecast is irrelevant if it does not address these specific demands, and the plan is impractical if it is not supplied with a reliable forecast.

With this correlation in mind, we will turn to an analysis of the sorts of information planners need in both demand and supply, in order to identify the basic elements of the relevance problem.

b. Analysis of Demand (Figure 20)

Since planning is essentially concerned with the future, planners require information in regard to both present and future ends, objectives and requirements. Where present and future demands differ, a change of policy is indicated; thus both are necessary.

The time range through which demand information is needed is again a function of the particular agency or actor. Operational and tactical units usually plan for one year; applied and developmental research organizations look five to ten years ahead, and basic research, strategic and general policy objectives range twenty years or beyond. Forecasting at longer ranges than needed is both costly and inefficient; forecasting at overly short ranges leads to plans and policies with a high probability of short-term gain long-term loss. The latter is by far the more common case, with long-term "backfires" considerably in evidence.

Present ends, objectives and requirements are based on one's own, or his agency's values. In many cases, these values are designated

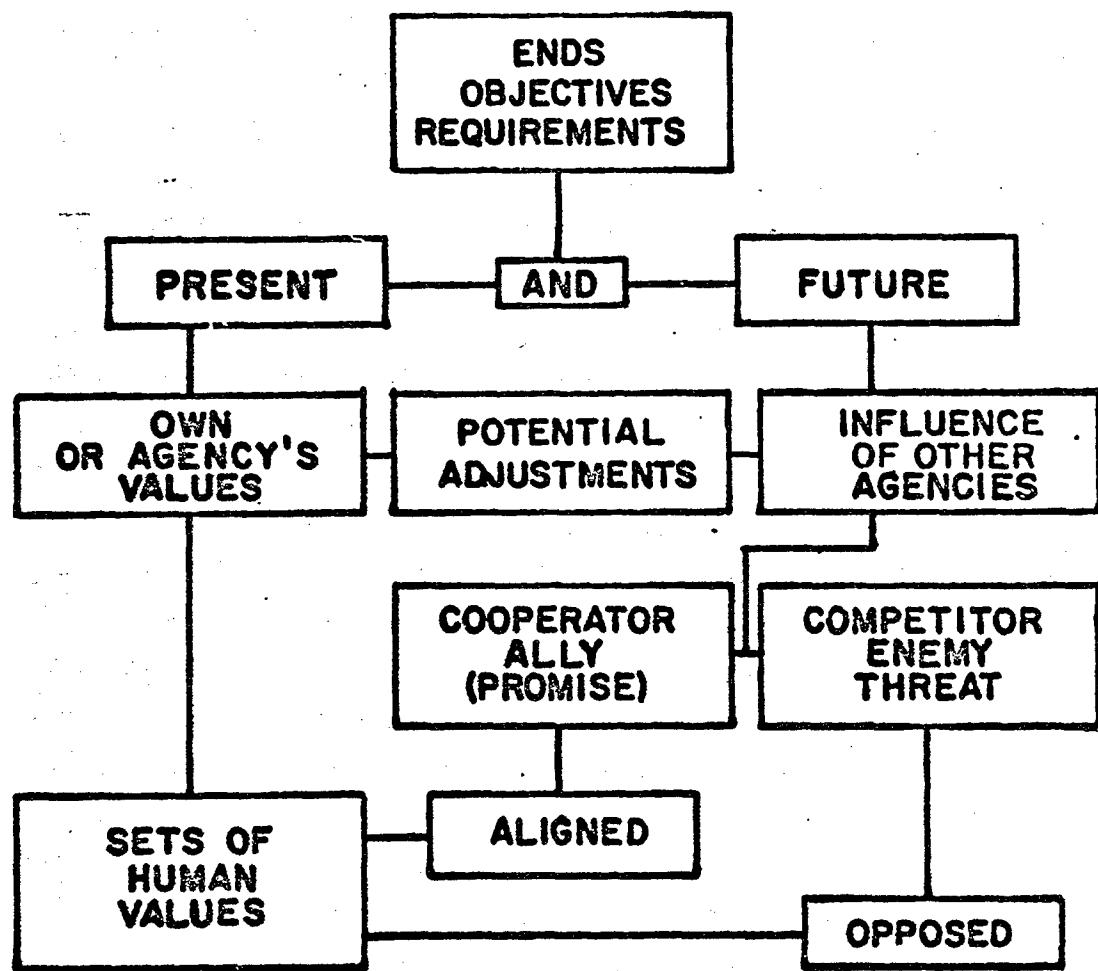


Figure 20. Analysis of Demand

as the mission or objectives of an organization by its parent or controlling agency. They are usually well recognized.

The most common method of ascertaining future demands is the implicit assumption that ends, objectives and requirements will remain essentially unchanged. For short-term forecasting, this assumption is often adequate, and slight alterations can be met as they occur. For longer-term forecasting, the assumption becomes progressively risky, and since the sort of agencies typically interested in long-term forecasts usually also have long lead times and slow response rates, they are not only in danger of surprise, but surprise at a point too late for effective correction.

A second approach is to forecast future demand by extrapolation of present and past trends. This technique is also adequate for short to middle ranges in many cases, but again, the assumption of continuance becomes hazardous at longer ranges. This is because extrapolation is incapable of showing forthcoming discontinuities or inflection points, and its potential for surprise increases with range.

A third approach is to analyze the future demand of a given agency for those factors which may cause it to change. These factors may then be extrapolated individually, and by analogy to their known relationships (sign and degree of causality), inflection of the whole may be indicated at some future period. This type of projection is called trend correlation, and is far more relevant to the needs of long range planners than are its alternatives. It is when we are forced to analyze demand for such individual factors that we discover the significant elements usually overlooked or excluded by the other techniques.

The major factor excluded by most extrapolations of demand is the influence of other agencies or actors. If this factor remains constant, one's own ends are also likely to remain constant, and the assumption of

similar requirements will prove to be valid. If changes in others' influence continue at the same rate as they have in the past, the technique of extrapolation will provide adequate information. But if this factor has been excluded, and subsequently changes at any other rate, surprise in the form of drastically altered requirements is highly probable, and whether or not a change of policy will have enough time to prevent drastic loss is questionable. Delayed response and overcorrection are both symptoms of inadequate anticipation.

Since this factor relates to actors or agencies, which agencies must also be specified. The main division is between those which will provide support or designate a change of values for the initial agency, and those which will provide threats in one form or another. The former include both subordinate and superior units or actors, and the latter include enemies and competitors. Any or all of these may influence the ends, objectives, and requirements of one's own agency.

The direction of such influence depends on the values of these relevant actors; the magnitude of threat or promise will depend on their means, capabilities and resources. Because their future actions are also based on normative decisions, both their demand and their supply must be considered.

Taking only the demand line for this analysis, we find the pattern continues through several stages, but finally rests on the various sets of human values aligned or opposed to one's own or his agency's. Analysis of demand will indicate which sets are relevant to any given actor's future demands, but in every case, it is in the area of human values that analysis stops. These are thus the basic problem elements of forecasting demand. Information in regard to what specified groups of people value is necessary if surprise is to be avoided in the forecasting of ends, objectives and requirements, including those of future Air Force missions and the needs future technology will be asked to fulfill.

c. Analysis of Supply

Planners also require information in regard to both present and future means, capabilities and resources. Again, the range to which such information is required will depend on their particular operation, with its characteristic delays, sequences and process lags.

(1) Present Supply information depends on knowledge of facts. Facts are realistic, in that they pertain to things which exist or do not exist regardless of anyone's belief. You either have such a capability, or you do not. The hazards of assuming one has more capability than he actually does, and the waste of assuming he has less, have led most forecasters and planners to a detailed search for the facts. Inventories, surveys, accounting systems, etc., serve the need for empirical fact-finding in most agencies quite well.

Most forecasting and planning activities appear to be vitally concerned that their perceptions of fact are accurate reflections of the actual condition of their own and others' capabilities. However, it must be stressed that decision and action are initiated on the basis of perceived capabilities, rather than actual capabilities. Various actors' perceptions are an important factor in projecting what they will attempt to do, as their actual capabilities are important in forecasting how successful or unsuccessful such an attempt is likely to be.

(2) Future Supply (Figure 21) shows to a greater degree than any of these analyses the basic problem elements involved in relevant forecasting, because more of them have to be considered.

The first division is between factors independent of all human opinion, and those which depend on some other agency's decisions. Both must be considered because the natural factors act as limiting or enabling parameters, and the humanistic elements underlie potentials for change within those parameters.

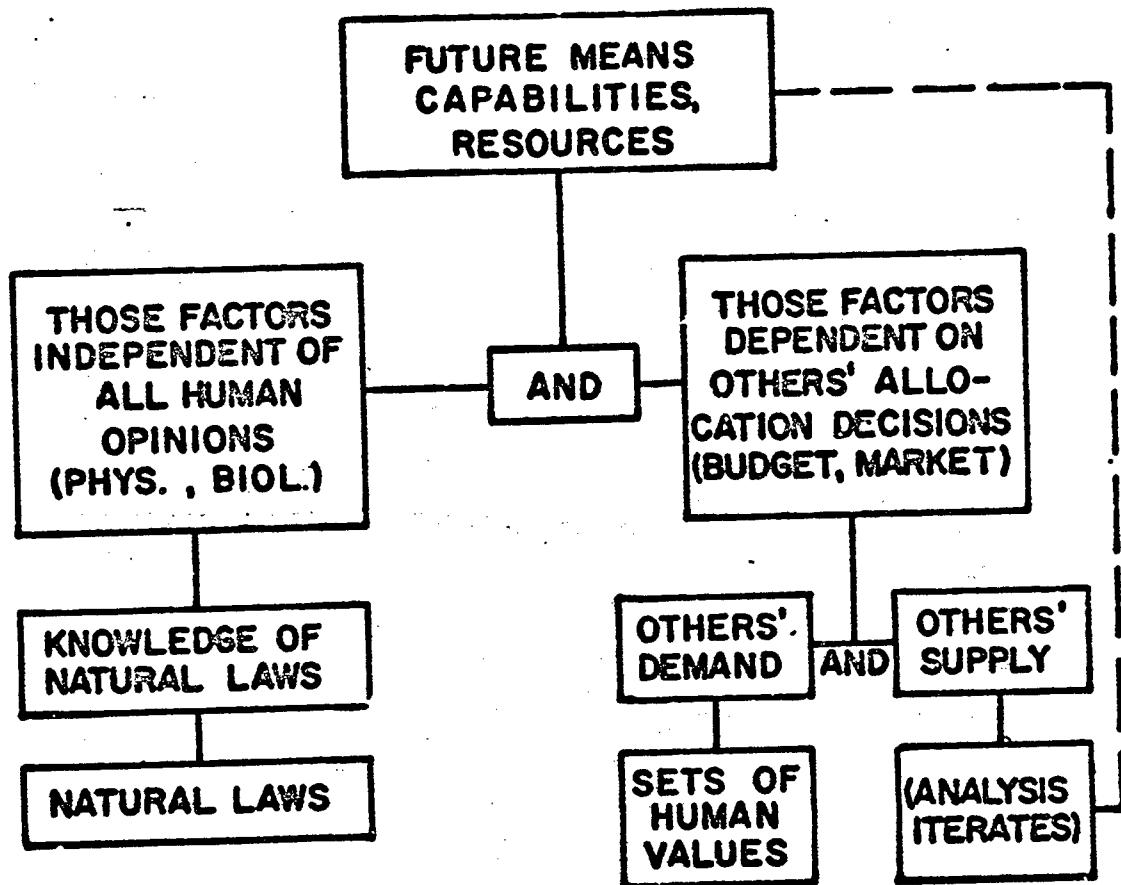


Figure 21. Analysis of Future Supply

On the natural factor side, there is also a perception filter; means, capabilities and resources will be fundamentally limited by natural laws, known or unknown; however, choices will be limited within present knowledge of these laws. The potential for nuclear energy manipulation has always been within the bounds of natural laws, but only with increased knowledge did it become a human resource or capability. Increasing such knowledge is a major avenue for improvement of forecasting (by knowing the limits), and for planning (increased latitude of choice). Here again, massive efforts are under way.

On the other side of the division, more and more forecasts are taking into account the influence of others' decisions, but still exclude a major portion. Others' decisions are also a correlation of their own demand and supply. Where human decisions underlie such vital areas as an agency's future budget, market, or threat, they contribute a highly significant portion of the information needed to ascertain that agency's future means, capabilities and resources.

Tracing down the demand line underlying a given budget, market, or threat leads again to the relevant sets of human values. Future capabilities and the purse strings follow the same path.

Tracing out the supply side leads to an iteration of the analysis, through essentially the same series of actors, with the demand side reappearing at every iteration. On the supply side, the factor of perception also continues to reappear as every agency will base action -- including the decisions to allocate or withhold resources -- according to perception rather than absolute fact. This then finalizes the analysis by completing a list of basic problem elements.

d. Criteria of Relevance

Having again followed the nature of underlying causes through a lattice of linked implications, we find a set of considerations

necessary for any forecast if it is to provide information relevant to planners and decision makers. Of these, two are in the area of realistic knowledge and concern factors independent of differing human opinions, and two fall into the area of humanistic knowledge concerned with what particular groups of people value or perceive. Together, they also provide useful criteria for the preparation and evaluation of forecasts.

(1) A Forecast Must Consider Relevant Sets of Human Values, beginning with those of the using agency, and including those of that agency's potential supporters or allies, and its potential competition or enemies. The forecast need not consider the values of any agency or actor unable to exert a significant influence for change in supply or demand during the forecast period. Thus, short-range forecasts typically need consider less actors than long range forecasts.

(2) A Forecast Must Consider the Perceptions of Relevant Human Agencies. Here, the using agency may be excluded if efforts are under way to ascertain actual conditions. Other agencies whose perceptions of fact are relevant follow the divisions of relevant values.

(3) A Forecast Must Consider Actual Facts Insofar as These May be Determined. This includes the actual capabilities of all relevant actors, and is required to project the likely outcomes of conflict and cooperation, as the humanistic factors are required for projection of initiation or onset.

(4) A Forecast Must Consider the Limitations of Known Natural Laws, essentially in conjunction with and for the same reasons as its consideration of actual facts. Both of these relate to what can and cannot be done -- or planned for with practicality -- within the forecast period.

3. Combined Improvement

When the criteria of relevance and reliability are applied jointly to a fairly representative sample of current social, economic, political, military and technological forecasting efforts, (Ref 58) they reveal a major imbalance between relevance and reliability, as well as the one between logical consistency and the validity of premises. In all areas of forecasting, the present situation is that projections which are acceptably reliable are only partially relevant, while those which are acceptably relevant are only partially reliable. Essentially, the smaller portion of the overall problem can be forecast fairly well, but the larger portion hardly at all.

2. Relevance

Except for the prediction of purely natural phenomena, the great majority of critical problem elements rests directly or indirectly on various clusters of aligned or opposed human values, and differing human perceptions. Forecasting is not only a normative activity designed to supply information needed by planners and decision makers, but most of its subject matter is also a normative combination of humanistic values and perceptions, and realistic facts or natural laws. Thus, the humanistic factors are highly relevant to forecasting anything which can be influenced by human beings. Such factors underlie:

(1) Any Forecast Involving Conflict, Cooperation, Competition or Assistance. This includes relations between social strata, economic classes, political entities such as factions, parties and nations, military threats, and technological assistance. In essence, it pertains to all relations between humanistic entities or corporate actors.

(2) Any Forecast Involving Ends, Objectives, Needs or Desires. This again includes all humanistic actors. A few examples are the nature of needed research, development and technology transfer,

the goals of social, economic and political planning, the nature and urgency of future military missions and the social needs technology will be asked to fulfill. These are all basically market forecasting.

(3) Future Allocations to any of these needs. This includes future research and development budgets, military manpower, equipment and resource allocations, and their industrial equivalents; hence, future military, technological and economic capabilities. These are basically production forecasting.

b. Reliability

At the present time, the realistic realm of knowledge is developed far beyond the humanistic. Knowledge of what any given group of people values or perceives is of questionable validity, usually due to ill-defined and untested assumptions.

Ignorance of humanistic factors makes effective forecasting impossible in any area influenced by human opinion, evaluation or belief. Certitude is again the primary barrier to improvement, under five headings:

- (1) The assumption that human behavior is inherently unpredictable.
- (2) The assumption that study of humanistic factors is not relevant to a particular area of forecasting.
- (3) The assumption that all men perceive and evaluate the same situation identically (rational man).
- (4) The assumption that present theories will adequately explain and predict human behavior, with a subsequent rationalization rather than investigation of their failures to do so.
- (5) The assumption that other people's values and beliefs are like one's own, already understood, and unchanging. This leads to dismissing others as irrational when the assumption proves to be false.

c. Typical Imbalances

(1) Technological Forecasting efforts tend to avoid the relevance/reliability dilemma by excluding humanistic factors altogether, assuming they will remain constant, or emphasizing only the impact of technical capabilities on these factors. By confining themselves to those aspects of technology dependent on the natural sciences, such forecasts are often acceptably reliable, but suffer from a lack of relevance. The excluded factors are the same ones which exert their influence over time to render the forecast ineffective.

(2) Social, Economic and Political Forecasts tend to rely on present theories without testing them, and to accept the opinions of experts as authoritative. This is a condition similar to many points in the history of natural science where development was arrested rather than facilitated. Non-replicable methods, implicit assumptions and lack of empirical validation make many forecasts in these areas of indeterminate reliability, even though they deal with highly relevant subjects.

(3) Military (threat) Forecasting efforts, although under considerable pressure to confine themselves to the natural sciences and technology, largely meet the criteria of relevance by including humanistic factors. However, they also tend to accept theories and experts without testing them; thus, they also suffer from indeterminate reliability.

d. Expectable Results of Imbalance

Either irrelevant or unreliable knowledge will lead to ineffective forecasting, planning and decision making. The general implication of ineffective forecasting, planning and decision making is surprise. A second implication in the case of long range forecasting is surprise at a point where it may be too late to take corrective action.

Because the presently lacking or invalid information pertains most strongly to demand, the characteristics of decision making imply that

surprise will concern the relevance of future capabilities. Thus, social, economic, political, military and technological surprise is most likely to be seen as:

The belated discovery that capabilities are urgently needed, but not available because the need was not foreseen.

The belated discovery that capabilities are available but no longer needed, because the change of need was not foreseen.

Together, these two forms of surprise may be described as being perpetually prepared to deal with the past, and perpetually unprepared to deal with the future.

e. Indicated Avenue for Maximum Improvement

The area of knowledge presently the most relevant and the least reliable is in the humanistic realm and concerns what other groups of people value or perceive. Because the primary barrier is certitude, we must first assume that we do not know what other groups value or perceive. The second barrier is ignorance; with the primary barrier removed, this may be reduced by diligent and persistent gathering of empirical observations, sequentially over time and precisely referenced, concerning the physical, written and verbal behavior of numerous humanistic actors. Which actors, and at what level, will have to be determined for individual forecasting efforts.

Compiled behavioral data will have to be carefully studied for either continuing trends, repetitious patterns, or preferably, both. Covariation, or like response by two or more actors to the same stimuli, will also prove valuable as a precursor of potential alignment.

These hypotheses of variation or covariation will have to be tested through retrodiction, postdiction, iteration or simulation.

By inferring from tested patterns of change what a given actor is working toward or away from, further insight as to that actor's goals

(values), and beliefs (facts) may be developed. These may then be further tested, and if supported, can be used for projection of long range objectives, strategies, and directions of action.

A second approach would be to take existing social, political, and economic theories as trial hypotheses, define them rigorously, and submit them to testing against empirical evidence. This also requires elimination of certitude and reduction of ignorance through compiling sequential observations of behavior. It is likely that many such theories would show acceptable predictive power under carefully delimited and specified conditions. Others might be denied entirely, but at any rate, their reliability would no longer be indeterminate.

Together, these two approaches may be described as empirical research in the human sciences; the first basic, and the second validation. Development of reliability in this area through application of the process, but not the products, of the more developed sciences is the primary avenue for improvement of long range forecasting, planning and decision making in all areas investigated by this study.

VIII. CONCLUSIONS

This section is designed to restate in as concise a form as possible the major findings of the study. Although many more insights were developed in the course of the research and are included in the body of the report, the following are considered to be fundamental.

1. Forecasting is a natural and universal activity of the human mind, a system of mental or logical processes implicit in all planning and decision making, applicable to any conceivable subject area, and capable of producing information in regard to future conditions. As such, it is essentially philosophical in nature, rather than being the exclusive property of any given subject area.

2. The mental or logical processes of forecasting include:
(1) deductive selection of subject areas relevant to the problem at hand or the purpose of the forecast, (2) inductive formulation of opinions regarding patterns of change suggested by compiled observations made sequentially in past or present time or process (3) transfer of such opinions from generating to using individuals, agencies or memory banks, (4) testing of induced or transferred opinions against further empirical observations (5) deductive projection of logical consequents into future time by assuming patterns of change incorporated by these opinions will either continue (trend) or repeat (analogy), and (6) remembering, recording, displaying, or transmitting these logical consequents.

3. The product of forecasting is called foreknowledge, but is actually no more than the necessary consequents of present knowledge or belief, exists only in the present, and is itself subject to change. It is to this extent alone that men may know the future, since the future is not amenable to direct observation and so presents no observable evidence.

4. The utility of foreknowledge is that it forms a prerequisite of effective power in the fullest sense of that term: the ability to consciously direct change. Human beings are powerless to alter the past and relatively powerless to alter the present. Only through the future effects of present actions do they actually cause change. While men can predict changes which they cannot cause, and cause changes which they cannot predict, it is only in those areas where they can combine these two abilities that they are able to control their environment.

5. Increased ability to cause change, such as an advance in technology, provides increased alternatives for action and thus increased latitude for choice. Increasing the alternatives requires an increased ability to forecast the outcomes of each before deciding between them.

Conversely, increased ability to forecast can increase the latitude of choice by disclosing otherwise unforeseen alternatives. Forecasting and the latitude of choice are directly related.

6. The two characteristics of an effective forecast are reliability and relevance.

(1) Reliability is a function of logical consistency and the validity of premises, wherein consistency may raise reliability up to, but not beyond, validity. For this reason, the scale of reliability which ranges from sheer guesswork through approximation and estimation to high quality scientific prediction is most closely related to the objective validity of entering assumptions.

(2) Relevance is the relationship between knowledge of facts and knowledge of values. In forecasting it is seen as the ratio between the information projected by a given forecast and the information desired by the planners and decision makers that forecast is designed to assist. This includes both subject areas considered and the causes of change underlying these subject areas. Relevance may vary from completely inappropriate considerations to a degree approaching but seldom attaining the inclusion of all pertinent considerations.

7. The result of ineffective forecasting is surprise, the symptom of belated recognition. Delayed response and overcorrection are also symptoms of ineffective forecasting. Short run gain with subsequent long run loss -- the "backfire effect" -- is a symptom of overly short forecasting ranges. Where ineffective forecasting is due to unreliable knowledge (logical fallacy or invalid assumptions), surprise will be constant over time. Where ineffective forecasting is due to a low degree of relevance (exclusion of significant causes of change), surprise will increase exponentially over time as the excluded elements exert their unaccounted-for influence for change. For this reason, the number of relevant considerations will increase in direct proportion to the desired range of forecast.

8. Forecasting includes four major modes of reasoning: induction, verification, authentication and deduction. Induction and verification are empirical and require the operational assumption of uncertainty. They act to increase the quantity and quality of knowledge. Authentication and deduction are rational and require the operational assumption of certainty. They act to transfer knowledge from one memory bank to another, and to apply it for the solution of practical problems. In all forecasts, the projection stage is deduction over time, with foreknowledge being the necessary consequent of present knowledge or belief.

9. The cause of ineffective forecasting is ignorance, a lack of relevant and reliable knowledge. Where knowledge is not available, forecasting is impossible; where it is incomplete, forecasts are only partially relevant, and where it is invalid or fallacious, forecasts are to the same degree unreliable. Ignorance is not knowing enough (quantity) or not knowing well enough (quality).

10. The barrier to improvement of forecasting is certitude, the assumption that present knowledge is adequately complete, consistent or certain. Where ignorance is not knowing, certitude is believing one already knows. It precludes the necessity of learning, and so the advance of knowledge by quantity and quality, and the improvement of forecasting by relevance and reliability. Because certitude is an habitual pattern of thought, it may be reduced by the operational assumption of uncertainty. This assumption marks the shift from rational logics (deduction and authentication) to empirical logics (induction and verification). Thus, empirical reasoning is required for the improvement of forecasting, as rational reasoning is required for its operational application.

11. The two major types of forecast are prediction and prescription, which are combined in the process of planning or decision making. Predictions are based on and project knowledge of realistic facts essentially

independent of human values. They deal with what can be (possibilities) or can be done (capabilities) in the future. Prescriptions are based on and project knowledge of humanistic values entirely dependent on the varying perspectives of individuals, corporate actors or agencies. In each case, every question of value must specify an actor -- value to whom? -- because human values are not universal. Prescriptions deal with what should be (ideals) or should be done (ethics) in the future, according to particular actors.

A relevant forecast of what will be (conditions) or will be done (actions) in the future must consider the predictions and prescriptions of the agency which will use the forecast for decision information, that agency's potential allies or customers, and its potential enemies or competitors. It must also include predictions based on natural laws, as they pertain to these actors. The prescriptions apply to the intentions and directions of effort of all actors, and hence to the initiation of conflict and cooperation. The predictions apply to capabilities and the likely success or failure of intended efforts by all actors, and so to the potential outcomes of conflict and cooperation; hence, the resultant future conditions. Future conditions in any area affected by human actions cannot be projected by realistic prediction alone.

12. The two basic techniques of projection -- whether applied to facts or values -- are extrapolation and prognostication. Extrapolation is the projection of trends on the assumption that patterns of change observed in the past and present will continue into the future. Its major weakness is the inability to predetermine an inflection point or discontinuity. Its major strength is ease of application. Prognostication is the projection of analogies on the assumption that patterns of change observed in the past and present will repeat under similar conditions in the future. Its major weakness is the inability to project at ranges

longer than those of the observed pattern. Its major strength is the possibility of continuing refinement over many trials.

Trend correlation combines these two techniques in a manner that tends to reduce the weaknesses of both. Complex systems are analyzed to underlying causes, which are extrapolated individually and then recombined by analogy to their known interrelationships. The extrapolations provide preconditions for the analogies, and the analogies allow the combined projection to show inflection points and discontinuities.

13. The testing of forecasts may be accomplished against either present or future evidence. Testing against future evidence requires waiting for the passage of time to make evidence available. In the case of long range forecasting, this involves a paradox wherein the forecast may be employed for decision and action, or tested against unbiased evidence, but not both. Testing forecasts against present evidence is possible because of the logical identity (deductive) of retrodiction, postdiction and prediction, which reason from present assumptions to the past, present, or future unknown. The requirements of such testing are: (1) replicable methods, (2) adequate definition, (3) explicit statement, and (4) relevant observable evidence. A forecast produced by such non-replicable methods as prophecy, intuition or expert judgment must be accepted or rejected on faith in the source. Vague, ambiguous, overgeneralized, or implicit assumptions, and those assumptions for which no relevant evidence is available cannot be tested in advance; thus, the reliability of forecasts based on them is indeterminate.

14. Reliable forecasts may be produced without consideration of cause and effect linkages. However, such forecasts are not relevant to the needs of planners and decision makers who will attempt to obtain or avoid the forecast condition, because they do not include the likely consequences of alternative actions. These consequences must then be

learned by potentially costly trial and error. Planners and decision makers need to know the linked chains of effects their alternate choices of action may cause. This is a major task of any relevant forecast.

15. While "self-fulfilling" and "self-defeating" predictions are an ever-present problem in forecasting and are always to be expected, the problem is not beyond remedy. Where such bias is a form of salesmanship, it may be reduced by use of independent evaluators. Where it is a matter of national, cultural, or academic predispositions, it may be reduced by diversification and dialogue such as interdisciplinary research. Personal bias is amenable to the same approach.

16. Finally, the problems and potentials of long range forecasting are those of organized knowledge. The effectiveness with which men exercise their historical ability to forecast, plan and decide, and so to consciously control the patterns of change, may be improved to a degree approaching, but never attaining, complete and absolute certainty. The quantity of knowledge which underlies degree of relevance may approach but not attain total understanding. The quality of knowledge which underlies degree of reliability may approach, but so long as time and change continue, never attain absolute validity. Thus, the manner in which long range forecasting of any or all subject areas may be improved is first to assume that present knowledge is neither complete nor certain, and then to systematically reduce uncertainty through the acquisition, organization, exchange and empirical validation of knowledge. The systematic reduction of uncertainty is an inherently endless process, and requires the concurrent realization that uncertainty will never be entirely eliminated.

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APPENDIX A

AN INTERROGATION MODEL FOR THE EVALUATION OF FORECASTS AND FORECASTING METHODS

In keeping with the requirement for making methods replicable and premises explicit, we have outlined a pattern of reasoning whereby criteria of relevance may be developed and criteria of reliability applied to estimate the potential effectiveness of forecasting in a given area, or of a given or proposed forecast or forecasting methodology. It should be stressed that such a model does not provide absolute answers, but only assists in organizing inquiry and evaluation.

Because any forecast is a normative activity, it must consider both values and facts, or as we have designated the terms, demand and supply. Because forecasting is a function of organized knowledge, its demand aspect involves what one needs to know and how well he needs to know it, while its supply aspect involves what he actually knows and how well he knows it. As in many normative situations, present practice tends to concentrate on a realistic appraisal of supply, and to neglect the humanistic appraisal of demand. Thus, in forecasting, we are more aware of what we already know than we are of what we need to find out. This model has been designed to incorporate both demand and supply aspects.

1. General Structure of the Model

The model has been designated as interrogation rather than analysis, because it employs a structured series of questions rather than statements. This tactic was chosen because it avoids the primary barrier to all inquiry, which is certitude; the assumption that we already know. Thus:

(1) The major premise of the entire model is that of uncertainty.
Like Clerk Maxwell and Socrates, we begin by assuming that we do not know.

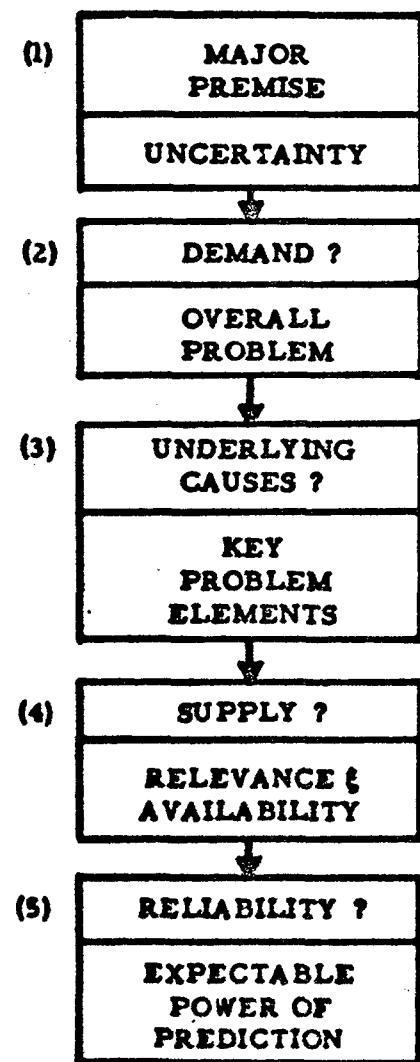


Figure A1. Overview of the Model

The reason for asking a particular series of questions in a given order is because the questions imply the criteria being used, and the order acts to: (2) identify the problem initially, (3) investigate the subject area in detail and condense the volume of details into key problem elements, (4) search for available knowledge by using the key problem elements as criteria, and only then (5) test the reliability of knowledge which is both relevant and available. This is the general structure and process of the model.

2. Interrogation for Demand

Under the major premise of uncertainty, the first theorem is that we do not even know what we need to know about the future. Questions which follow from this theorem pertain to the purpose, goal or objectives of the forecast. They attempt to identify the demand for knowledge this forecast will supply or fulfill. Answers imply criteria of relevance by actor, subject, criticality and range. They are all idealistic, in that they pertain to unfulfilled desires rather than to objective realities.

(1) Who needs this forecast? Because demand for anything rests on human values, and human values are not universal, it is necessary to identify not only value, but value to whom. The answer to this question will identify a corporate actor or entity; an agency, company, department, nation or ideology. It may also include more than one such actor. In most cases, it will refer to the initiating agency or the customer of the forecast. In any event, all subsequent questions must be explicitly relevant to this identified actor, which will be referred to as "we."

(2) What are we interested in knowing about the future? This will depend on the area of operation or activity of the actor. The answer should be given in the most general terms possible to prevent unnecessary

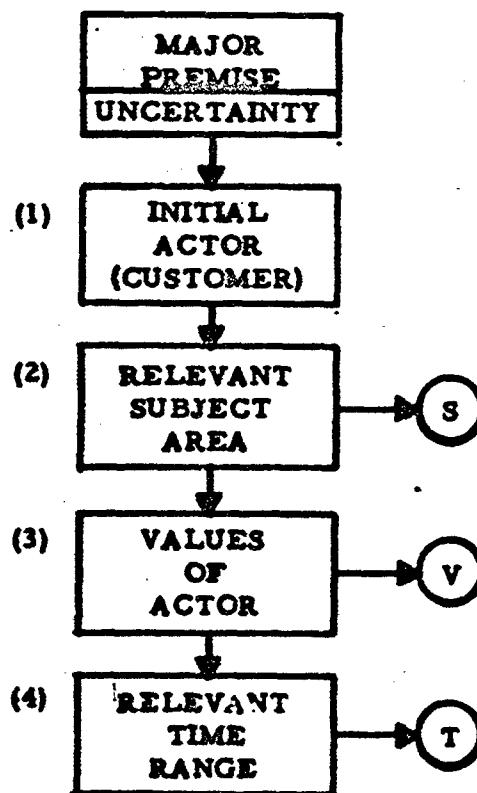


Figure A2. Interrogation for Demand

limitation of the subject area or areas. It should be stressed that this question is designed to identify, but not to define. The subject area may well have to be modified if the next stage of interrogation discloses basic problem elements tacitly excluded by the agency in its own definition. In some cases, the subject area may be narrowed, but most agencies appear to exclude relevant parts of their problem by overly narrow definition. Hence, the need is to identify the broad subject area of concern.

(3) How badly do we need this forecast? This question relates the general subject area to the value-structure of the actor. It addresses the criticality or elasticity of demand. Its answer will depend on what the actor is seeking to avoid or obtain; that is, his overall ideals, ends, objectives and goals. Some actors will hold corporate survival as primary goal; others will have service to a parent agency, nation or ideology as their fundamental objective. In any case, it is these goals or objectives which must be studied in order to ascertain the meaning of gain and loss, the relative criticality of basic problem elements, the cost of error, and the marginal utility of surveys, validation studies and basic research. In essence, it establishes criteria of value which will be used to decide how accurate this forecast has to be.

(4) Through what future time-range do we need to forecast? The answer to this question requires study of the operation in which the actor is engaged, with specific attention to rates of change, sequences, lags and delays inherent in such an activity. In general, it will identify average elapsed time from information availability through planning, decision making, programming, construction of facilities and production to the point where a substantive output may be expected to impact on reality. How far we need to look into the future depends on how long it will take us to accomplish what we are trying to do.

The answer to this question will be a number of years, the relevant time range. It will be used to establish a cutoff for the scope of the problem. Those elements which cannot be expected to exert a significant influence for a change within this period may be projected as constant; those which will may not be so projected. Since more elements will exert an influence over longer ranges, the necessary scope of any forecast will be proportional to its desired range.

3. Interrogation for Underlying Cause

The uncertainty theorem in this stage of the model is that we do not know what may cause changes in the subject area of the forecast. An additional assumption is that change is not entirely random, but caused. This assumption is required by the purpose of the interrogation, which is twofold: (1) to disclose otherwise hidden elements of the problem, and (2) to establish the cause and effect linkages which are vital to planners and decision makers when they attempt to obtain or avoid a forecast condition. Random factors are, by definition, those for which no cause may be assigned. Therefore, it is more appropriate to isolate such factors by inability to disclose their causes than it is to assume all factors are random from the start, and so fail to look for causal linkages.

Three major points should be stressed. (1) the line of this interrogation runs backward, from effects to causes. This is because the general subject area of the forecast is taken as a future effect, and the questions look to see what, if changed, could cause it to change. (2) the interrogation must be accomplished both exhaustively and sequentially. Exhaustively, to show all conceivable causes for each effect, and sequentially, to show linked chains of underlying causation which will lead to change in the general subject area. And (3), the interrogation is not looking for answers or definitions, but for underlying problems. It seeks to identify what we need to study in order to provide a forecast relevant to this actor.

It should be noted that interrogation for cause follows the logic known as a relevance tree, which it constructs specifically for the general subject area and the actor "we." Like any such tree, it will expand in number of details at each level. However, it is unlike most relevance trees in that it enters with an effect and branches out to underlying causes, where the more usual application enters with a cause and branches out to its subsequent effects. The latter is appropriate for analysis or projection, but not for interrogation.

(1) In what ways can this general subject area change? Here the subject area identified by interrogation for demand is taken as input, and questioned to identify its general dimensions of change. This is necessary in order to give meaning to such terms as "increase" and "decrease." Basic distinctions in this area are between changes of demand and changes of supply, between changes of quantities and changes of qualities. All conceivable types of change should be considered.

(2) Which of these changes do we see as desirable and which do we see as undesirable? Increases and decreases along each dimension of change should be labeled as of positive or negative value. In some cases, we will not know whether a given change is desirable or not; here we may give it the sign of uncertainty, "?". Such question marks are a valuable output, as they identify something we need to know.

(3) What can cause these changes? Here we are looking for the nature of causes in very general terms. Each type of change will have to be questioned exhaustively because most will have several necessary causes of change, none of which are sufficient by themselves. One type of change may have differing causes for increase and decrease. There may be causes which are neither necessary or sufficient, but only contributory. And again, many causes may be unknown, calling for the question mark and further investigation in the next stage of the model.

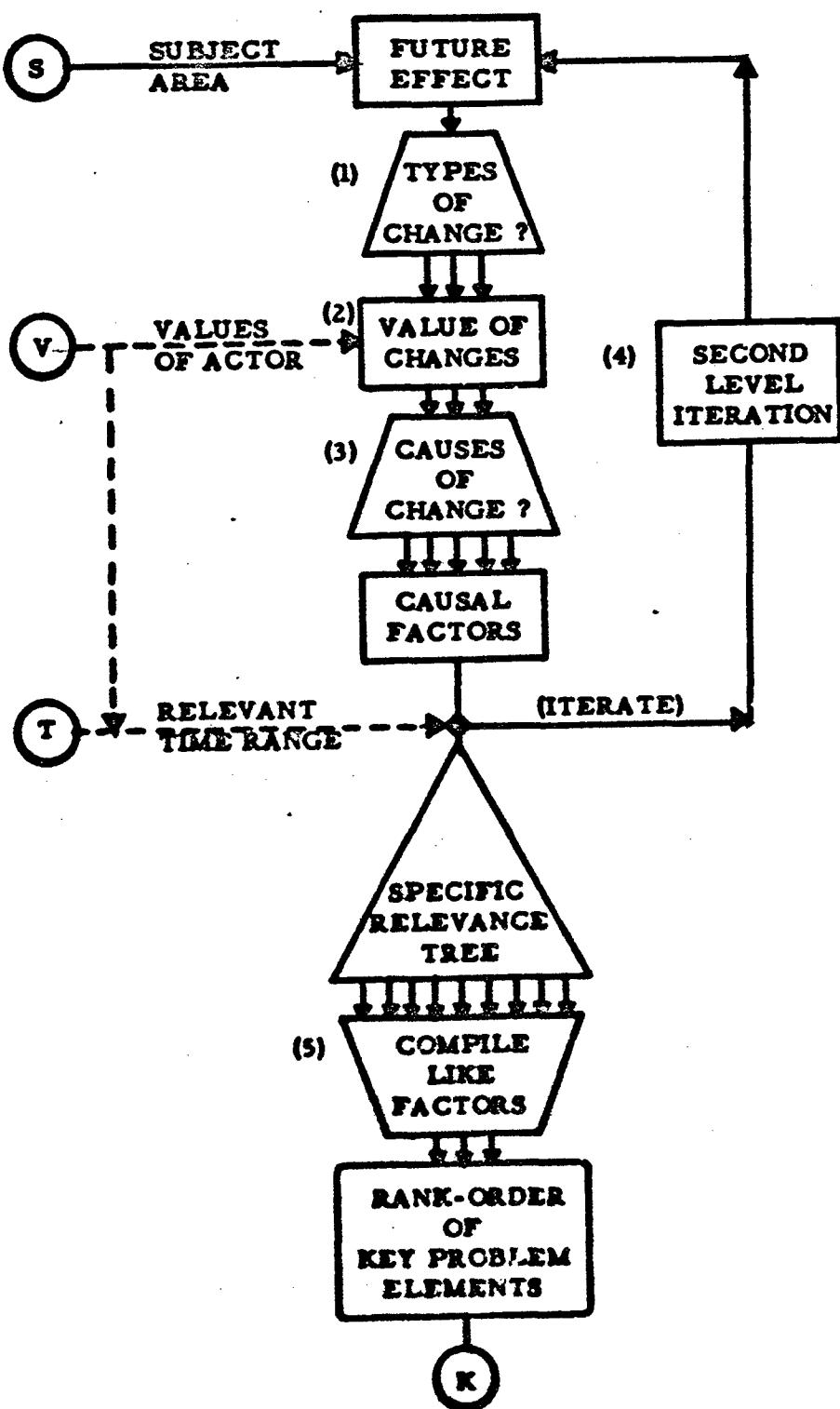


Figure A3. Interrogation for Underlying Cause

In attempting to identify all conceivable causes of change, a series of secondary questions is necessary. These pertain to humanistic causation, and are often overlooked. However, they are highly critical. In our own applications of the model, we find the great majority of all changes caused by humanistic factors.

(a) Can human actions cause any of these changes? This question is used to discriminate between humanistic and natural factors. Where change is not caused by human actions, one may ask "What can cause this change?" However, where human actions do cause change, a different question is required.

(b) Whose actions can cause this change? Here we attempt to identify the relevant actors. Answers will be in the form of individual human beings either within or outside the initial actor "we," groups, factions, agencies, nations, etc. All of these are humanistic entities or actors.

(c) What sort of change is this actor likely to cause? That is, without doubt, the most difficult question in the model. In almost all cases it will be unknown on initial interrogation. The sort of change caused by any given actor will depend on what he intends to do and what he is capable of doing. Both of these are items for further investigation.

(d) In what ways can these factors themselves change? At this point the interrogation for cause iterates to the second level by taking each identified factor of change (including the actions of relevant actors) as a future effect and searching for underlying factors of change. Questions (1) through (3) are repeated, with special attention to the causes underlying change of behavior by the relevant actors. As the iterations continue, causes of changed behavior will be found to lie in the way each actor perceives reality and the values he assigns to what he perceives. Other actors may be identified at the second and subsequent levels, as

their actions influence the demand or supply of those on higher levels. In all cases of humanistic causation, however, the final question will be: "How do they see things, and what do they value?" The question cannot be answered in this stage of the model.

Interrogation for cause continues to iterate through as many levels as necessary, with the relevant actors, their perceptions of fact and of value, their capabilities, and various nonhuman or natural factors falling out at every level. While these are usually the inputs for another interaction, they are not reentered if: (1) they are not identified; i.e., the question marks, (2) they cannot be expected to contribute significant change to the general subject area within the relevant time range, (3) they are found to be noncritical, or, (4) when the most recent level of interrogation has disclosed no new elements, but only repetitions of those previously identified. To speed operation of this stage, an arbitrary cutoff criterion may be established at each level, and only the more critical factors taken into subsequent iterations. When the tree has been exhausted by any or all these cutoff criteria, one question remains.

(5) What are the key elements of this subject area? This question may be answered by compiling like causes of change that repeat many times across the lowest levels of the tree. This includes those actors whose influence underlies many branches, the natural factors which do the same, and the question marks. These may be rank-ordered by the number of times they appear, or the proportion of the tree they affect. They are the key problem elements, causes with many effects, and they represent both the inputs and the preferred sequence for the next stage of the model.

4. Interrogation for Supply

The uncertainty theorem in this stage is that we do not know what information is available concerning the question marks and key

problem elements identified in the previous stage. The assumption is necessary, because if we assume we already know what is and is not available, we are likely to overlook significant sources of information. Taking each question and key element individually, we ask the following.

(1) What do we know about this area? We direct the first question to the most immediate sources of information; those which are on-hand or in-house, because it is more efficient to do so than to go immediately to external sources. Answers will be in the form of concepts, methods, principles, properties, functions, causal relationships, etc. As these are located, the problem elements we have taken from the relevance tree are used as criteria to determine both the relevance of what we know and the availability of what we need to know.

The results of matching what we know with an identified problem element will fall into one of three classes: (a) knowledge which is both relevant and available, (b) knowledge which is relevant but not available, and (c) knowledge or expertise which is available, but not relevant to this particular problem. The first may go directly into interrogation for reliability; the second represents an unfulfilled demand, a requirement for additional surveys; and the third is a surplus capability which may remain in storage pending identification of a problem to which it applies.

(2) Who should know something about this area? The elements of unfulfilled demand now become the criteria for surveys of external sources; libraries, data banks, the accessible literature, experts from other departments, agencies, disciplines, etc. The surveys may be accomplished in many ways, from personal conversation to specifically designed survey contracts. The object is merely to locate potential sources of the needed information. Cutoff criteria for such surveys come from a balance between the criticality of the problem element and the time or money available.

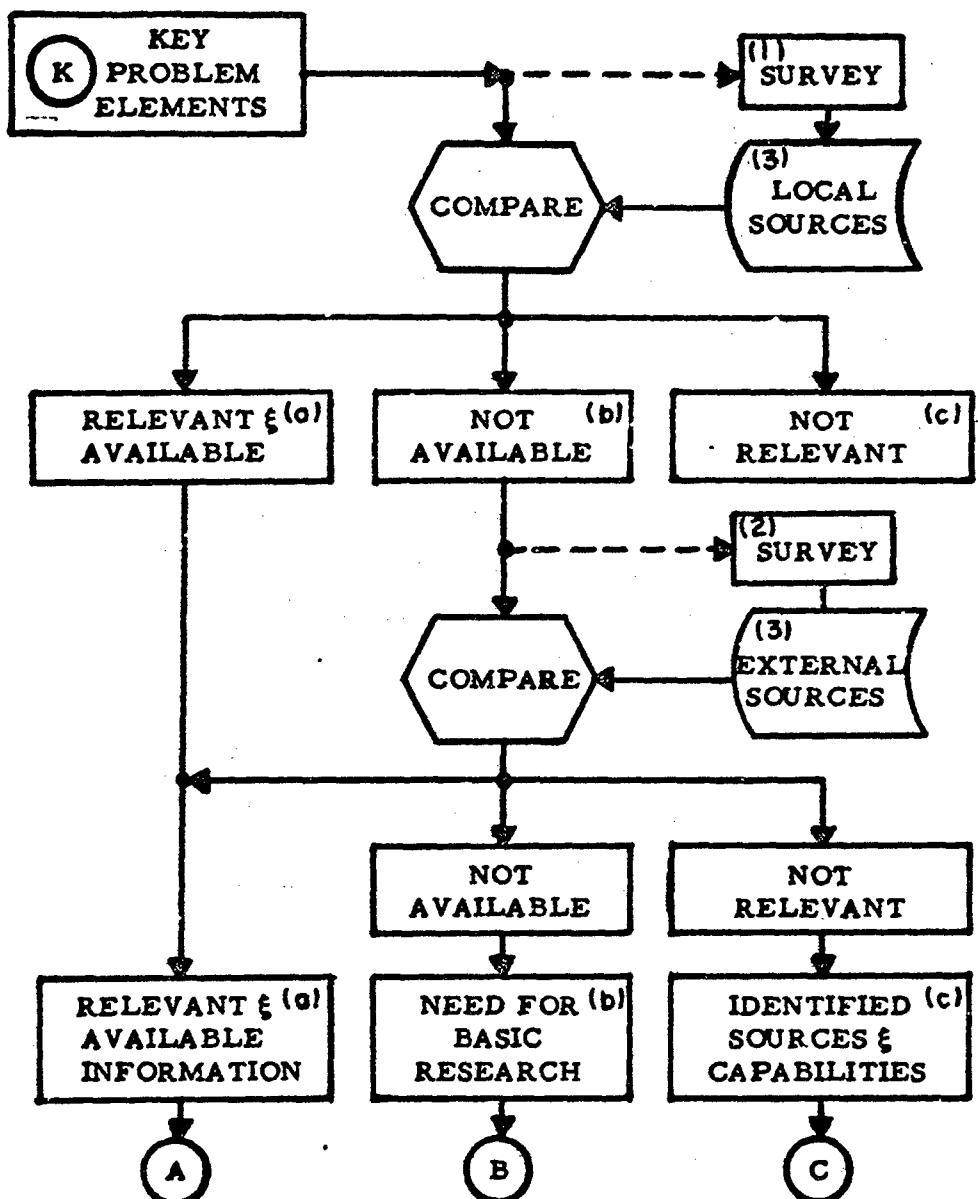


Figure A4. Interrogation for Supply

(3) What is known about this area? Regardless of where relevant sources are located, they must be mined for their information. This is the "buy, borrow, beg or steal" aspect of research. At times, the information will have to be paid for in cash, at other times it may be recompensed with nothing more than a footnote or a word of thanks in the introduction. Often it is not paid for at all. In any event, one will never be able to collect everything that is known about any particular problem element. The best he can do is to make himself acquainted with the fundamental principles and recent developments. If he later is called upon to construct a forecast for this subject area, he will have to go into far greater detail, but at least he will know where to look.

Information found in these surveys will take the same forms as that found in answer to question (1), and will fall into the same three classes: (a) relevant and available, (b) still needed but not available, and (c) encountered along the way, but not relevant to this particular problem. The first goes into interrogation for reliability, and the third represents an identified capability that can be stored for future reference, but the second is now a residual demand for information, a problem for basic research.

The decision whether or not to initiate basic research may now be made on the basis of an identified need. The worth or utility of a study proposed by such a process may be estimated by the potential effect that discoveries in this area would have on the overall subject of the forecast and the operation of the initial actor. If this impact is minor, research may be deferred and the resultant errors in the forecast accepted. If it is not, the subject, the relevance, and the criticality of a new basic research project will have been established.

Only at this point in the model does the sort of information necessary for basic research allocations become available. At this point we have a

fairly good idea of what we need to know, why, how important or unimportant such a study would be, and we are fairly confident that it will not be a duplication of something already available. Consideration may now shift to estimating the potential costs of the study, the probability of success through its potential for support from other areas, and by comparison to the criticality estimate, to cost effectiveness. So far as we are able to determine, this is the only way other than intuition by which the cost-effectiveness of basic research may even be approached.

5. Interrogation for Relevance

There is an alternate channel at this point in the model, which is used when evaluating a preexistent forecast or forecasting methodology. Because the information is already available in the forecast, we are only concerned with its relevance. Because the first question in ascertaining the relevance of anything is "relevance to whom?" and this is identical with the first question of interrogation for demand, it may be seen that what we actually do is to lay the forecast aside and begin from the beginning of the model. We go through interrogation for demand and interrogation for underlying cause, to the point where we have identified the key questions and problem elements. These then become our criteria of relevance.

The key problem elements are then matched with the topics or subject areas included in the forecast or accounted for in the methodology. This comparison will fall into the same three classes as interrogation for supply; (a) those topics found to be both relevant and included, (b) key problem elements overlooked or excluded by the forecast, and (c) topics which are included in the forecast, but are not found to be relevant to the overall problem. Disposition of elements that fall into these classes is also the same, with only the first being taken into interrogation for reliability.

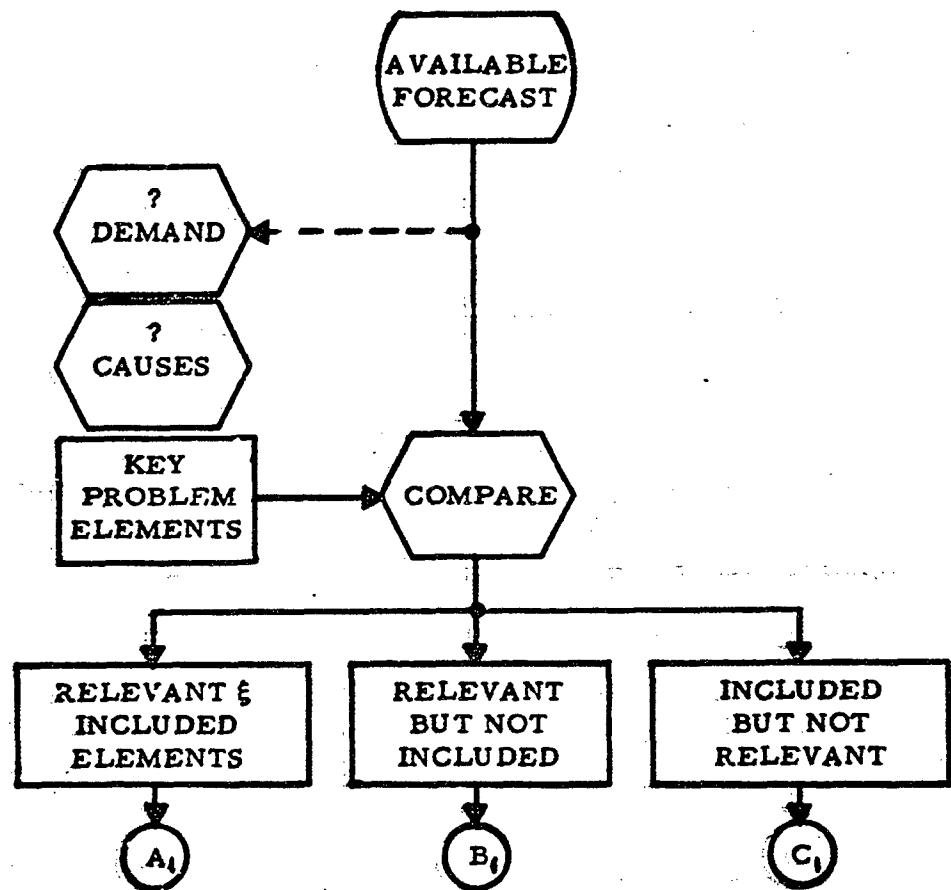


Figure A5. Interrogation for Relevance

6. Interrogation for Reliability

From whatever source it is obtained -- personal opinion, local expertise, external surveys, preexistent forecasts, or newly developed by basic research -- all information found to be both relevant and available must be interrogated for reliability. The uncertainty theorem here is that we do not know how well we know. We cannot afford to accept this information at face value.

(1) Are the methods replicable? A replicable method is simply one in which the pattern of reasoning can be followed from beginning to end. This question applies to forecasting methodologies and to the patterns of reasoning by which laws, principles, assumptions, etc., are applied. Prophecy, intuition and much of expert judgment will fall out here, as being of indeterminate reliability. "Black box" predictions and assumptions, like those obtained from a crystal ball, must be accepted or rejected on faith alone, rather than by systematic evaluation. While faith has its place and purpose, it cannot be recommended for this role.

(2) Are the logics formally consistent? This is the only useful question which may be asked of the methodology itself, once it has been found replicable. It applies only to the rational logics; deduction, prediction, evaluation, etc. It does not apply to the empirical logics such as induction. This is because the prime criterion of formal consistency is that the conclusions must be necessary consequents of the premises or assumptions employed. This does not apply to empirical logics because their consequents do not necessarily follow from but are only suggested by the data.

The rules of formal logic which follow from the prime criterion may be applied at this point for the identification of fallacies. If found, a formal fallacy will render unreliable all conclusions from that point in the methodology onward.

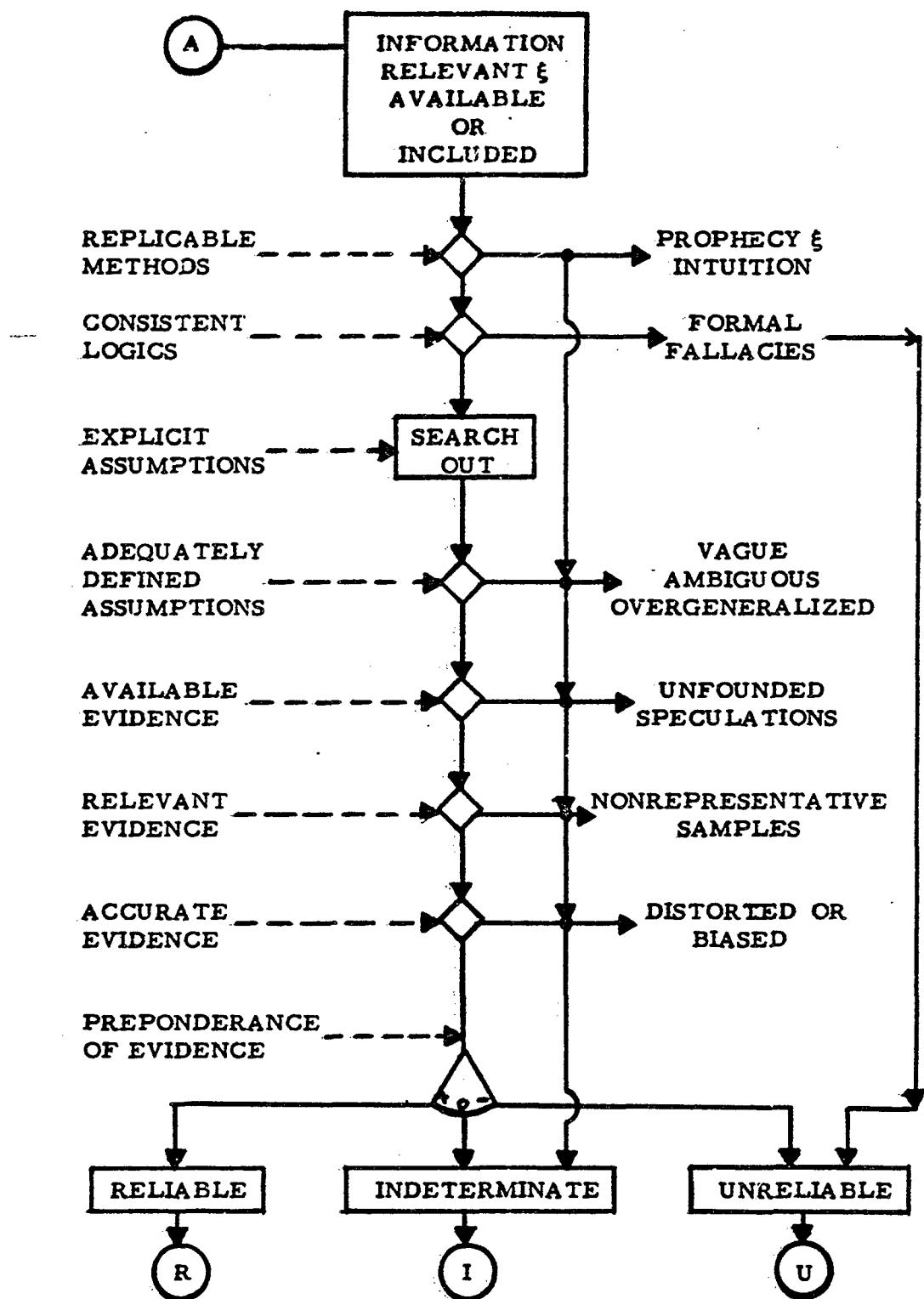


Figure A6. Interrogation for Reliability

(3) What are the assumptions? Under assumptions, we include all laws, principles, axioms, hypotheses, theories and premises. We take all of these as being merely assumptions because of the uncertainty theorem which leads us to question them. This is another antidote for certitude, which would tend to accept or reject them out of hand.

This question leads us to search for implicit assumptions, which must be dug out and made explicit before any evaluation of their reliability may be accomplished. Answering this question will consume a great deal of time because it requires us to reason backward from a number of conclusions or predictions to their implied premises or assumptions. The most vital of these is, of course, the initial major premise of the method or methodology.

(4) Are the assumptions adequately defined? By adequate definition we mean that a particular assumption specifies the conditions to which it does and does not apply, and the evidence necessary for affirmation or denial. Here, vague, ambiguous and overgeneralized assumptions will fall out as being untestable. An inadequately defined assumption will render all conclusions or predictions deduced from it of indeterminate reliability.

In several recent forecasts nearly all of the major assumptions were inadequately defined. Because of this, reliability of the entire forecast was indeterminate, even though its logics were formally consistent and most assumptions made explicit.

Some secondary questions which will assist in determining whether definitions are adequate are as follows.

(a) Is this a static or dynamic assumption? Static assumptions refer to states or conditions, and must specify a particular point in time. While we find a large number of assumptions which imply eternal constancy because they are given as static and do not specify a point

in time, ("The nature of man is . . ." "All Frenchmen are . . ."), such assumptions appear to be inadequately defined. If eternally constant phenomena actually exist, it would be pointless to forecast them. Within dynamic (changing) systems, no condition or state may be defined without giving a specific point in time or in a process.

Dynamic assumptions involve a rate, acceleration, sequence, delay or causal linkage. In this context, the assumption of "no change" is dynamic rather than static, because "no change" means "zero rate over time." All dynamic premises must specify a dimension of change, and an interval of time.

(b) Is this a realistic or humanistic assumption? Realistic assumptions are those concerning phenomena essentially independent of differing human opinions. Most of these are found in the natural sciences, but they also include the past or present behavior of human beings. Such assumptions must specify the phenomena to which they apply.

Humanistic assumptions refer to the values, perceptions, future actions, intentions, goals, etc., of human beings. Each of these assumptions must specify the particular group of people -- the corporate entity or actor -- to which it applies, because it may be completely irrelevant to another group or actor. Any assumption of value, worth, cost or risk must also state value to whom.

(5) How valid are the assumptions? There are two ways in which the answer to this question may be approached, although they rapidly converge. These are submission to authority and submission to evidence.

(a) Is this assumption a necessary consequent of authoritative laws, principles, axioms, or their embodiment in the opinions of authoritative persons? This is submission to authority, and as may be seen, it merely sets the problem of establishing validity one level back

into abstraction. One must either accept the validity of the authority on faith, or submit it to empirical evidence. This holds whether the authority is a set of axioms or a person. Thus, submission to authority does not actually establish validity; it only assists in disclosing the parent assumptions whose validity must be established.

When such parent assumptions are disclosed, it is they and not their deductive consequents which must be questioned, and the questions are identical to those necessary when assumptions are not deduced from authoritative axioms. Only in those cases where the axioms have previously met the requirements of empirical validation may their consequents be validated by their authority.

(b) What evidence is available to support or deny this assumption? This question is necessary because even when an assumption is defined so as to tell us what evidence to look for, how, where, and what sort of observations will constitute affirmation or denial, that assumption is still not valid, but only testable. If no evidence is available, its validity and so the reliability of all conclusions deduced from it are still indeterminate.

The problem in answering this question is sufficiency of evidence. Because the sort of assumptions used in forecasting contain a time function or rate (dynamic premises), the evidence necessary for absolute confirmation or denial will not be in until the forecast period has expired. Thus, the only available evidence will lie in the present or past, and this will never be sufficient for absolute confidence. For this reason, the sufficiency or insufficiency of evidence is always a matter of judgment. However, this judgment may be assisted by employing a few more questions.

(6) Is the evidence relevant to this assumption? As always, relevance is the relationship of supply to demand. In this case, it is the

relationship between the type of evidence available and the type of evidence demanded by a given assumption. In general, the nature of evidence required follows the divisions noted for adequate definition of assumptions. Criteria are:

(a) Evidence to support or deny a static assumption must derive from the particular point in time specified by that assumption, or the particular stage of a dynamic process. If an assumption refers to one point in time or process, and the evidence is drawn from another, the evidence is irrelevant and cannot be used for validation. A good deal of the errors in forecasting and the difficulty in evaluating forecasts comes from failure to specify the exact time at which observations have been made. Temporal precision has long been mandatory in the natural sciences, and is an obvious avenue for improvement of forecasting in other areas.

(b) Evidence to support or deny a dynamic assumption must be gathered sequentially in time or process. Because dynamic assumptions refer to an interval of time, they cannot be validated by evidence taken from only one point in time. Such evidence must be gathered by sequential observations, each precisely referenced in time, for a period and at a frequency of observation relevant to the particular assertion being validated. Fast, short-period changes require many observations in a brief span of time; slow, long period changes require less frequent observations but over a longer period. Where such observations have not been made and recorded, dynamic assumptions cannot be validated for lack of relevant evidence.

(c) Evidence to support or deny a realistic assumption (fact) must be gathered from sources, processed and presented as free from human evaluation and prejudices as possible. This is because what people do or do not believe is irrelevant to matters of fact and only serves to

bias the facts if it is included. This shows the specific utility of being objective, and of using replicable methods. Only when any person who makes an observation or performs an experiment according to specified procedures can come up with the same information, may differing human opinions be removed and the evidence considered to be realistic.

Realistic evidence may be obtained from any observable phenomena independent of human opinion, including those which are not normally observable but have been made so by our technological extensions of the human observational capacity. This includes most of the subject matter in the natural sciences, the biological sciences, and past or present human actions. In any of these, however, phenomena which are not observable may only be validated by deducing from testable assumptions (trial hypotheses) those necessary consequents which are observable. These observable consequents then provide the criteria for relevant evidence.

(d) Evidence to support or deny a humanistic assumption (value, perception) must be obtained from physical, written or verbal behavior of the particular corporate entity or actor to whom the assumption refers. This is because different groups of people may perceive the same facts in differing ways, and because human values do not refer to reality but to a desired or undesired condition which exists only in their minds. Thus, realistic facts are irrelevant for ascertaining the validity of an assumption in regard to what people believe or value. Further, evidence gathered from one group or actor may be irrelevant to an assumption concerning another group or actor.

Because the subject-matter of humanistic assumptions exists only in human minds and not in objective reality, all humanistic phenomena are nonobservable. As assumptions in regard to such nonobservable phenomena as energy fields are validated by observing the patterns of

observable behavior they cause (such as the tracks energized particles make through cloud chambers), so humanistic assumptions may only be validated by observing the behavior patterns of specific humanistic actors.

There is no other source of evidence relevant to assumptions in regard to human perceptions, values or beliefs than through observations of the past and present behavior of human beings. In this sense, behavior must include verbal, written and physical; i.e., what they say, what they write, and what they do. These are the observable consequents by which humanistic assumptions may be validated. If information of this sort is not available, no humanistic assumption may be validated, for lack of relevant evidence.

(7) How accurate is this evidence? This question also relates to how well we know what we think we know, but at the level of data rather than assumptions or premises. Here, we may distinguish between uncertainties of observation or measurement, and conscious or unconscious distortion.

(a) Uncertainties in observation are, in the first instance, an inherent property of any sensor, human or nonhuman. They include distortion of the field by the sensor itself, the exclusion of data to which the sensor is not receptive, and the limited degree to which a given sensor can detect small gradations of condition or change of condition. As shown by the Heisenberg uncertainty principle, these distortions cannot be entirely eliminated. They can, however, be significantly reduced by use of sensors (or people) specifically designed (or trained) for sensitivity to a particular field, and the use of multiple sensors which include a wider span of data and tend to cancel out each other's distortions. In the social sciences, some data gathering techniques such as sample surveys by questionnaire show a large tendency to distort the field they

attempt to observe. How evidence was gathered and by whom, are important items in ascertaining the quality of data.

(b) Uncertainties in measurement are not uncommon even when observed data are fairly precise. They may occur when numerical data are aggregated and presented with a single figure, rather than with a confidence interval. For instance, population figures are usually given in this way, when it would be more correct to present them as estimates, with plus and minus confidence intervals. Numerical precision, like temporal precision, must be built from the bottom up. Where figures are not certain, they disguise distortions if they are given as certain. In looking for the quality of data, what was dropped out or hidden by measurement and aggregation can be significant.

(c) Conscious distortion is a matter of prejudgment, where the observations are distorted to fit preexisting human values. It tends to preclude a representative sample because the human sensor or source selects only such evidence as will confirm his own prejudgetment. The indicated approach for estimating the direction and degree of such bias is similar to that of identifying the intentions of humanistic actors. From the patterns of earlier behavior on the part of a given source, one must infer the source's predilections; i.e., "What ax does he usually grind?" "What is he trying to sell?" From such an assessment of the source's motives, one may estimate the direction of likely bias. By how strongly he holds these views, one may infer the likely magnitude of distortion.

There is nothing new in this technique of inferring motives from patterns of behavior. Decision makers do so constantly on an ad hoc or in-head basis. To be more specific, they do it every time someone walks into the office with a sales pitch. The only difference in the matter of biased evidence is that the salesman may not be recognized as such, and especially in numerical data, the distortion overlooked. Because

conscious distortion is a humanistic problem, a humanistic approach is required. One needs to check the predilections of the data source.

(d) Unconscious distortion is a function of the philosophy, culture, and especially the academic discipline of the human sensor. While several observers may test and correct each other for individual biases, it is very difficult to identify a pervasive bias or predilection which they all share. The origin of such unconscious and unintentional distortion lies in the "self-evident truths" of the culture, the unchallenged axioms of the discipline, or the implicit assumptions of the common philosophy. These are used in both selection and classification of data; thus, they show up as an implicit bias in the evidence.

Once the presence of conscious or unconscious distortion is identified or suspected, the means of reducing it are similar to those employed for nonhuman sensors. Several sources may be consulted, with varying biases, in order to cancel out the distortion. This is why students are urged to reference more than one source in the preparation of any research paper. Even though any one source of evidence may be distorted, the forecaster and evaluator of forecasts may reestablish a representative sample -- and so a basis for estimating the validity of assumptions in that area -- by balancing the bias of his sources.

Cancelling of both conscious and unconscious distortion is a major asset of the consensus of experts (DELPHI) technique, and of interdisciplinary research. Interagency and international seminars, etc., also assist in this regard.

Another approach is similar to selecting one's sensors for minimum distortion of the field. Since many of our sensors are human beings, we may employ them only in those areas where each is the least likely to be biased. When we know that a particular individual is highly biased in regard to -- let us say -- politics, while at the same time maintaining

scientific objectivity as a biologist, we are more likely to obtain unbiased information in the latter than in the former area. Application and systematization of this line of reasoning may be found in a modification to the selection of experts, called TORQUE. It was developed by a tri-service ad hoc committee assembled by the Department of Defense (DDR&E). In this approach, experts are only called on to present evidence or opinions in the areas where they are likely to be most expert and least biased. This would appear to be a sound and needed refinement.

(8) Does the preponderence of evidence tend to confirm or deny this assumption? It is at least potentially possible to absolutely confirm or deny any assumption which refers to past or present conditions, provided it involves only observable phenomena. Assumptions in regard to nonobservable phenomena (including all humanistic assumptions), and those which refer to future changes or conditions may never be absolutely confirmed or denied. In these cases the best one can hope for is a level of confidence somewhere in between. Whether or not this level of confidence is acceptable will depend on the criticality of a particular assumption: the more critical, the more confidence is required. This is also a matter of judgment.

(9) The outputs of interrogation for reliability do not fall into absolutely distinct classes, but rather fall along a spectrum that ranges from reliable (+1), through indeterminate (0), to unreliable (-1).

Those areas of a forecast affected by a logical fallacy or an assumption absolutely denied by the evidence are unreliable and cannot be employed.

Those areas affected by non-replicable methods, an inadequately defined assumption, or an assumption whose validity is indeterminate for lack of relevant evidence, are of indeterminate reliability. These may provide information in regard to needed research in much the same

manner and with the same sort of details as that identified by interrogation for supply. Rather than strictly basic research, however, these call for more rigorous definition, gathering of relevant evidence, and empirical testing. The indeterminate assumptions may fill the role of trial hypotheses.

Those areas of knowledge which have survived interrogation for reliability by meeting all of the questions successfully may now be viewed as relevant, available, and acceptably reliable. They may be employed in forecasting with a reasonable degree of confidence.

7. Estimation of Potential Effectiveness

The simplest and most direct way to estimate the potential effectiveness of forecasting in a given subject area is to take the number of key problem elements (which are already weighted by degree of impact and criticality to the actor) for which knowledge was found relevant, available and reliable, and divide it by the total number of weighted problem elements. On the illustrations, this would be to divide all information which had survived through interrogation for reliability (connector R) by the total information coming out of interrogation for underlying cause (connector K).

The potential effectiveness of a forecast or forecasting methodology may be estimated in exactly the same manner. However, it is often useful to note whether lack of effectiveness is due to exclusion of significant elements (irrelevance) or to weak power of prediction (low reliability). This differentiation can provide an indication of needed improvements.

Degree of relevance is a decimal between 0 and 1 which is obtained by dividing those elements for which relevant knowledge was found available (A or A_1) by the total of key problem elements (K).

Degree of reliability is another decimal between 0 and 1, obtained by dividing the positive side of interrogation for reliability outputs (R) by the total inputs to this stage (A or A_1).

In the estimation of overall effectiveness, the degree of relevance may be multiplied by the degree of reliability to show a final decimal between 0 and 1, degree of potential effectiveness. Again, these are only rough estimates and not precise figures. They are, however, systematically arrived at by a replicable method.

8. Interrogation Model Read-Outs

In the course of trying to estimate the potential effectiveness of forecasting in a given subject area, or of a particular forecast or forecasting methodology, we find a new additional pieces of information which can be valuable.

Read-outs of the model include:

- (1) Information in regard to needed basic research, with its subject area, relevance, criticality, and a fair degree of confidence that it will not be a duplication of information already available.
- (2) Information in regard to needed validation studies, with the same sort of details as those listed above.
- (3) Information in regard to sources, expertise, etc., which accumulates throughout the model and is organized for further reference.
- (4) Estimated degree of relevance for a given forecast or forecasting methodology.
- (5) Estimated degree of availability for information required to forecast in a given subject area.
- (6) Identified areas or subjects where power of prediction is acceptably high, or unacceptably low.
- (7) A fairly rigorous estimate of how effective a given forecast or methodology will be.
- (8) A fairly rigorous estimate of how well present state-of-the-art can be expected to forecast in a given subject area.

APPENDIX B

CUSTOMER'S CHECKLIST

Decision makers are the primary consumers of forecasts, but they rarely have time to go through a detailed interrogation model such as the one presented for evaluators. Therefore, we suggest an abbreviated version which covers the major points. While the specific questions may vary for particular operations and decisions, the following appear to be basic.

1. Why do we need this forecast? The answer to this question should include overall relevance of the forecast by subject area, range, scope, and criticality in terms of the operation and values of the customer "we." To answer this question adequately requires study of that operation and those values.

2. What portion of our decision information does this forecast project? This question leads both forecaster and decision maker to consider the total context and basic problem elements. It also implies that some elements may have been excluded; an awareness of the total context will indicate what additional information will be required for decision. Basic considerations here will be demand and supply aspects, to include the influence of other agencies or actors.

3. What method was used for projection? A one-word descriptor will not suffice to answer this question. Extrapolation, analogy, or combinations of the two should be identified, and whether the processing was done by intuition, expert judgment, consensus of experts (DELPHI), optimum selection of experts (TORQUE), a relevance tree (PATTERN), etc. The decision maker needs to know the limitations inherent in the method employed, including whether or not it is replicable.

4. What are the assumptions on which this forecast is based?

While the answer to this question may be voluminous, it directs attention to the fundamental input problem and requires explicit statement of premises. It also allows the forecast to be analyzed and evaluated in detail, rather than accepted or rejected as a whole.

5. How well have these assumptions been tested? This implies a requirement for adequate definition and empirical evidence. Appeal to the authority of axioms or experts is not an acceptable answer, unless the authorities themselves can show they have successfully withstood empirical testing. The predictive power of each assumption must be demonstrated.

6. What are the sources? Annotation of sources will assist in determining if evidence is relevant (realistic, humanistic, specific point in time, or time series), and whether humanistic evidence was gathered from the actor or agency specified. This is a requirement of replicability, and for the reduction of bias.

These are the sort of questions which we feel any decision maker should expect a forecast to answer before he bases decision and action on its projected conclusions. They are also questions which any forecaster should be prepared to answer before he presents his conclusions.

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